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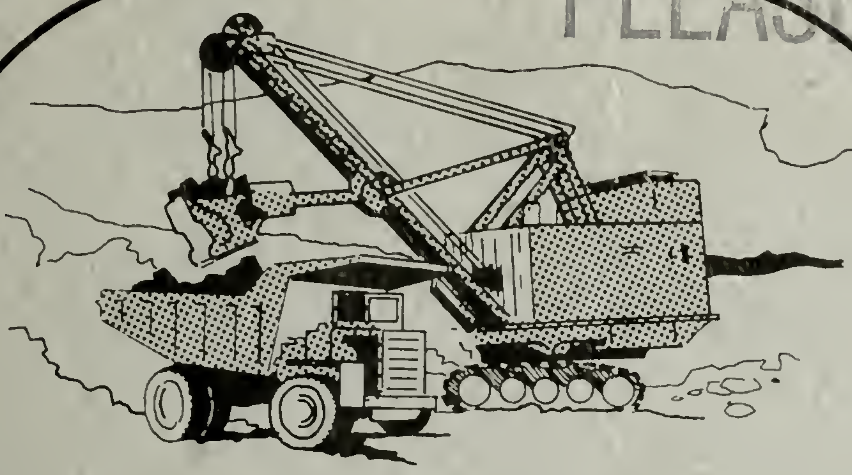
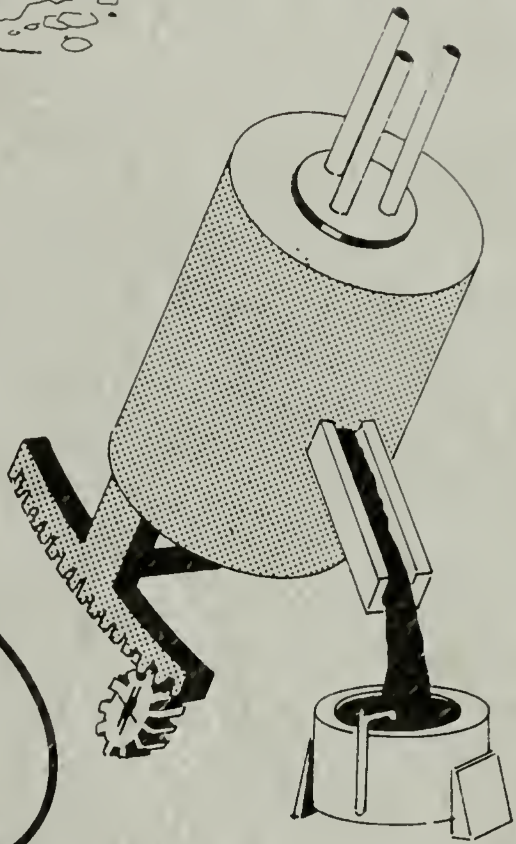
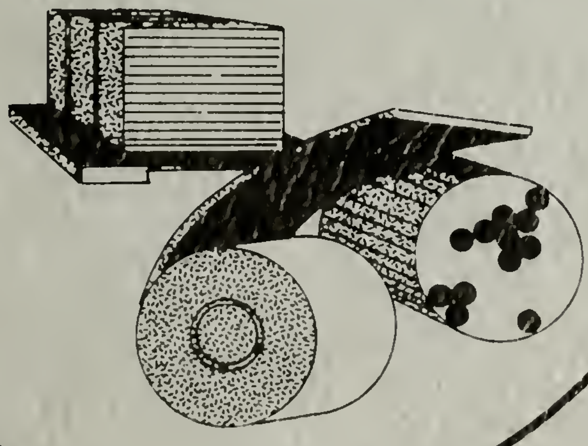




FEASIBILITY OF DEVELOPING A STEEL INDUSTRY IN MONTANA



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FEASIBILITY OF DEVELOPING
A STEEL INDUSTRY
IN MONTANA

Prepared for:

Economic Development Division
Montana Department of Community Affairs
Capitol Station
Helena, Montana 59601

Prepared by:

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August, 1975

This study was performed under contract with the Economic Development Division. The statements, findings, conclusions, recommendations, and other data in this report are solely those of the contractor and do not necessarily reflect the views of the Economic Development Division.

ACKNOWLEDGEMENTS

Guidelines, ideas and information for this report were obtained from many sources. We especially thank the following individuals for their assistance. Their fine cooperation provided a significant contribution to our effort.

Dr. Sid L. Groff, Director
Montana Bureau of Mines and Geology
Butte, Montana 59701

Mr. Lee L. Hietala, Administrator
Economic Development Division
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Helena, Montana 59601

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I. INTRODUCTION

Background Information

The State of Montana is relatively rich in mineral resources. Many iron ore deposits are known to exist, but very little development and utilization of these deposits has taken place. Information on these resources is sketchy, and the true development potential is speculative.

Recent shortages and price increases in steel and steel products have spurred a renewed interest in developing heretofore untapped resources. The economic feasibility of utilizing low grade and locationally remote resources is changing. These factors, plus the current high level of interest in economic development (essentially in creating new jobs and income), have resulted in the decision to pursue the development of a steel industry in Montana. The State Economic Development Division has thus authorized this study.

The intent of this study is to analyze the feasibility of developing a steel industry in Montana. Consideration is to be given to the State's goal of achieving vertical integration of such industries within the State. Thus alternatives are herein considered for both ore processing and steel manufacturing. Hopefully steel raw materials would stimulate additional manufacturing within the State. Included in the analysis are identification and evaluation of available resources, process alternatives, markets, and cost factors.

It is recognized that the complexity and magnitude of a truly comprehensive analysis are beyond the scope of this study. Ore sampling, process tests, and other technical aspects of evaluation are not included. Nevertheless, this study identifies the scope of alternatives, evaluates key factors,

draws general conclusions, and points out specific areas requiring more detailed study.

Summary

While spatial variations do exist in the several cost elements in iron and steel production, the element most subject to geographic variation is total transportation cost. A major goal of management in location decision making must be the minimization of that transportation cost. Unfortunately, a Montana location has a transportation disadvantage. No compensating advantages exist which are sufficiently large to counteract this disadvantage. A Montana plant location would have a cost of operation about 12.5% higher than similar U.S. plants. This disadvantage amounts to about $17 per ton of finished product. This is caused mainly by the cost of shipping raw materials. The shipping of the finished product is also considerably higher than average because of the dispersed market area. Montana taxes also create a relative cost disadvantage in comparison to most states.

Based on the preliminary feasibility study it appears that a mini steel mill would be marginally profitable in Montana. Since only a small market exists it is recommended that a 150,000 ton/year electric furnace/merchant mill operation be analyzed in detail. A market of approximately 1,000,000 tons annually of merchant mill products exists in the West (excluding California). The proposed mill would need to capture 15% of this market. The proposed mill should be able to obtain this amount.

The international steel demand will continue to be strong for the foreseeable future. U.S. steelmaking will be able to compete favorably in this market. The market situation looks especially good in the Western U.S. The long range outlook for Western U.S. steelmaking is therefore encouraging.

The availability of capital for investment is a major problem, however. Since return on investment is usually less than 8% on steelmaking ventures, it is not an attractive business opportunity.

The source of iron and coal are major problems. No Montana deposits have been verified that are presently commercially and technically suitable. If scrap is used the need for iron ore and coal is eliminated. However, the scrap would need to be shipped long distances. There may not be enough scrap within a reasonable distance to support a mini-mill. In this event direct reduced ore could be imported if local development weren't possible. If direct reduction of local ores could be accomplished, then the reduced ore could be substituted for scrap. A 6% savings in the total finished product cost could be gained by eliminating transportation distances. Further investigation needs to be made into the feasibility of direct reduction of Montana iron ore deposits. The probable size of this operation would be 300,000 tons/year. A mini-mill would utilize about one-half of the direct reduction plant output, the rest would be shipped out of state.

If a Montana iron ore development other than direct reduction were pursued, the entire production would be shipped out-of-state since a mini-mill must use either scrap or direct reduced pellets.

Energy requirements (in the form of electricity and natural gas) are critical items that are unpredictable at the present time. Further substantiation of their availability and cost needs to be performed. The following summary outlines the major requirements. Note the enormous amounts of natural gas required by the direct reduction process. The electric furnace of the mini-mill consumes large amounts of electricity also.

Major Operating and Capital Requirements Summary

Mini-Steel Mill:

- 600 people
- $31.3 million capital investment
- 16,000 KVA electrical power

Mine/Direct Reduction Plant:

- 100 people
- $25 million capital investment
- 3.6 billion cubic feet natural gas/year (or equivalent coal)

Since a large labor force is needed, ancillary services are vital, and good transportation services are mandatory; the steel plant will need to be located in an area that is already industrial and has a large population.

A conventional mill which uses concentrated iron ore is not feasible. Economies of scale require that such a mill be larger than a Montana based market could support. This type of mill is roughly 10 times as large as a mini-mill. The absence of suitable local coking coal also seriously hinders this alternative.

The electric mini-mill process is adaptable to stainless steel production, should it become feasible to develop this approach.

II. MARKET

World Demand Forecast for 1975-1985(1)

Unprecedented demand projected for iron and steelmaking matallics for 1975-1985 will create new global forces that are expected to alter the trends and directions of the steel industry worldwide. In spite of forecast record

---

(1)Source: Engineering and Mining Journal, September, 1974.

demand, it is anticipated that the required tonnages of steelmaking materials will be available. Prices of iron and steel raw materials, services, and products will continue to rise in a market that will place a high premium on quality, service, reliability, and environmental and resource management.

Fundamental changes have taken place in the nature of the demand for ferrous metals. To an increasing degree, the world's major consumers of iron units are no longer interested in iron values alone: what they want is iron content that is combined both with energy units and what may be described as pollution-tolerance values. This wholly new pattern is manifested in the continued purchase of steel scrap—almost anywhere in the world where it is available.

All the raw material inputs required for the volumes of global steel production anticipated for 1975-1985 will be available. These necessary raw material inputs include not only metallics—such as screened, concentrated, and agglomerated iron ores, ferro-additions, and directly reduced iron ore and scrap—but also coking coal and, significantly, energy and pollution-tolerance units. Material availability will become sufficient through the conversion of potential resources to economic reserves as a result of new technology, increased price schedules, and widely dispersed steel industry activity around the world. The funds needed for new facilities will be formidable—approximately $190 billion during the next 10 years. Of that amount, one-quarter will be spent on mines, mining and ore processing facilities, and ocean-going transportation.

Globally, steel scrap supplies will be adequate for 1975 but will be in close balance after 1980. Consumption in 1975 is projected at 375 million

tons, increasing to 550 million tons 10 years later, with 85% of the total going to steel production. Scrap consumption of this magnitude for steel exceeds that of any past year. Unfortunately, these figures are also close to the combined potential of the industry to generate circulating or plant scrap, and the ability of the scrap industry to recover and prepare salvage scrap. These two sources together may produce a small worldwide scrap surplus for 1975, but for 1980 and 1985, a balanced situation is expected at best.

Scrap supply in the U.S. is somewhat greater than abroad, particularly in view of this country's traditional role as the world's leading producer and exporter of steel scrap. Furthermore, the use of effective fragmentizing and other recycling equipment may facilitate greater recoveries from the large U.S. reservoir of salvage scrap than have thus far been achieved. Relief will also come from a continuation of the North American scrap industry's shift from open hearth to oxygen steelmaking techniques and from a worldwide increase in the use of electric arc furnaces with charges containing significant portions of directly reduced iron.

However, improvements like these in steel scrap in the U.S. cannot fully alleviate the critical worldwide situation for some years to come. At present, steel scrap shortages are universal in spite of—and perhaps because of— large export shipments from the U.S. Prices have jumped by more than $100 in 1974 from approximately $42 per ton only eight months earlier. Prices are currently around $55 per ton.

Prices for iron and steelmaking metallics, like those for practically all other basic raw materials and products, may be expected to continue to move upward. It's also clear the steel market is growing faster than anyone expected. The growth factor still being used in many forecasts is 2½ percent.

There are those who feel a 4 percent growth rate is realistic for the rest of the decade. The question of capacity began cropping up with predictions that world steel needs would be over a billion tons by 1980. With 380 million tons of new raw steel needed and 320 million tons of replacement capacity, the world's steel producers would have to duplicate existing facilities by the end of the decade. Exhibit 1 shows the projected demand and supply figures.

U.S. Steelmakers Capacity(1)

U.S. Steelmakers are out to boost capacity another 15 million tons. This will be provided in a surprisingly short time; the bulk of the new capacity should be on stream by 1977. If the projections are right, another 10 to 20 million tons of basic capacity will be needed by 1980. This second increment will require expansion from the ground up--from ore mines through iron and steel furnaces.

There is no general rush to start projects for 1980. Bethlehem Steel Corp. and National Steel Corp. have fairly detailed long range programs. However, there have been few commitments for the future and in many cases, new projects have not even reached the planning stage. Companies are holding back for the same reasons that have been given over the past five years. It takes well over $600 an annual ton to build greenfield capacity. After a long depressed period, steel men want to see a better return on past investments before they go ahead with new ones.

According to one projection, the indicated steel expansion by 1980 will total 17 million tons. Depending on which market estimate is used, this

---

(1) Source: Iron Age, July 22, 1974.

EXHIBIT 1

WORLDWIDE STEEL SUPPLY AND DEMAND

Distributions of Steel Process Use Worldwide (in percent)

Year	Oxygen	Open Hearth	Electric	Bessemer
1955	-	74.7	7.7	17.8
1960	3.8	68.5	10.3	17.4
1965	16.4	59.0	12.0	12.6
1970	41.5	38.8	13.8	5.9
1975	52.7	30.7	14.4	2.2
1980	62.0	17.1	20.0	.9
1985	65.0	6.5	28.0	.5
1990	62.0	3.8	34.0	.2
2000	57.0	1.9	41.0	.1

Comment: O_2 and EF methods will account for 67.1% of world total steel production in 1975; 82% in 1980; and 93% in 1985, compared with 28.4% in 1965 and 55.3% in 1970.

Estimated Scrap Generation Potential Worldwide (million mt)*

Year	Raw Steel Production	Estimated Total Scrap Required	Potential Scrap Generation		
			Plant & Process	Capital & Salvage	Total
1969	577	330	185	145	330
1975	735	375	254	152	408
1980	915	490	317	167	484
1985	1,025	550	360	193	553

Comment: Balanced scrap generation capability shown after 1980.

Estimated Demand for Prereduced Iron Ore Worldwide (million mt)

Year	For Steel Production		For Iron Production		Total
	MT	%	MT	%	MT
1975	11.2	100	-	-	11.2
1980	42.0	65	22.0	35	64.0
1985	88.0	71	36.0	29	124.0

Estimated Fe-metallic Requirements Worldwide (million mt)

Year	Raw Steel Production	Estimated Requirements			
		Iron Ore	Scrap	Prereduced Iron Ore	Manganese Ore
1975	735	910	316	11	23.5
1980	915	1080	407	64	28.3
1985	1025	1250	460	124	30.8

*mt = Metric Ton = 2204 pounds.

Source: Engineering and Mining Journal, September, 1974.

will be 8 to 17 million tons short of raw steel needs. These numbers are not misleading. Steel officials are the first to warn that a large deficit is entirely possible for the future. On the other hand, it would be a mistake to regard the outlook as hopeless. The recent increases in steel prices should go a long way toward generating confidence in continued profitability.

For the next 10 years and probably longer, basic steel is going to be a coal-based industry. Five new coal mines, with combined capacity of over 10 million tons a year, are being opened up. The reason for this emphasis is obvious. Coal is available to American steel mills in almost unlimited quantities. For some time to come, most of the nation's coal will be coked in conventional slot ovens. Eight of these are being built.

Down the road somewhere may be formed or pelletized coke. Now in startup is a pelletizing plant at Sparrows Point. Sponsored by Bethlehem and a number of other steel companies, this pilot operation will turn out 500 tons a day. Operating tests and blast furnace performance tests are expected to run about a year. One big advantage of the new method is pollution abatement.

Already underway is an expansion of iron ore properties. Six new projects include a 10-million-ton addition of concentrates at U.S. Steel's Mt. Wright mine in Quebec, and the Hibbing, Minn., project which will give Bethlehem another 6 million net tons of iron pellets. The ore programs bring out the fact that steel companies are doing more than simply balance existing facilities. Others are also starting to provide the raw material base for integrated expansion.

To some steel people, there is enough overall saving to make a large blast furnace mandatory. That leaves the problem of fitting a giant furnace into the rest of the company's production facilities.

With regard to steel refining, there seems to be no question the basic oxygen process will be the workhorse of new plants. Three new oxygen shops are being built in this country and Canada. Various improvements are being made at other locations.

Electric steelmaking is very much in the expansion picture. Electric furnace mini-mills continue to spring up all over the country. The current problem for electric furnace shops is the price of scrap. Direct reduction would help in this regard but most reduction processes require natural gas, which isn't available in most steel producing areas. Another possibility is that the SL/RN process, which uses solid carbon as a reductant, will prove attractive. Coal gasification could be important for direct reduction.

Continuous casting is now generally favored for the conversion of raw steel into semifinished steel. Five new casting installations have been started by the larger mills. Exhibit 2 is a summary of the planned expansion in the U.S.

Future of the Steel Industry in the West(1)

For years, the western part of the U.S. had been suffering from disproportionate import of steel relative to the rest of this country. Now because of the world steel situation, the area is suffering from a shortage and in some cases paying premium prices.

For the entire decade of the 1960's, imported steel was coming into this market area in increasing quantities. Three years ago, foreign steel

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(1) Source: Iron and Steel Engineer, November, 1974.

EXHIBIT 2

U.S. STEELMAKING CAPITAL SPENDING

Steel Expansion Starts

More than 10 million tons of new raw steel capacity will be added by these companies:

U.S. Steel—5 million tons—1976.
Bethlehem—1.6 million tons—$500 million—1977.
National Steel—1 million tons (750,000 finished product) $300 million (2 million by 1980).
Jones & Laughlin—1 million tons—$200 million.
Youngstown Sheet & Tube—750,000 tons—$200 million (another 650,000 second phase).
Kaiser Steel—200,000 tons.
Allegheny Ludlum—10% expansion—$22 million.
Keystone—40,000 tons.

Raw Materials

Iron Ore
- Hibbing, Minn.—5.4 million ton pellet plant. Bethlehem's share of venture with Pickands Mather, others.
- Minn.—2.6 million tons, taconite mine with pellet plant, Inland. Also new ore boat.
- Minn.—Pellet plant, National, also new ore boat.
- Quebec—10 million tons of concentrates, Mt. Wright, U.S. Steel.
- Quebec—Fire Lake, U.S. Steel.
- Liberia—Exploration, Republic.

Sinter plants
- Sparrows Pt., Md.—Bethlehem, replaces six small machines.
- Fontana, Calif.—Kaiser—improvements.

Scrap
- Pueblo, Col.—CF&I acquired area's largest scrap processor in 1973.

Coal Mines
- West Va.—2.5 million tons a year, Republic.
- West Va.—1 million tons a year, Armco.
- Pa.—2 million tons/year, $50 million, Youngstown.
- Pa.—4 million tons/year, U.S. Steel.
- Ala.—3 million tons/year, U.S. Steel.

Coke and Coal Gasification

Coke Batteries
- Aliquippa, Pa., 1978, Jones & Laughlin, Pipeline charging.
- Aliquippa, Pa., 1976, Jones & Laughlin, Modernization.
- Follansbee, West Va., 79-oven, Wheeling-Pittsburgh, $60 million, replacement.
- Bethlehem, Pa., Bethlehem.
- Indiana Harbor—56 ovens, 2500 tons/day, Inland, pipeline charging.
- Indiana Harbor—85 ovens, 2700 tons/day, Youngstown.
- Gary—U.S. Steel.
- Middletown, O.—Armco.

EXHIBIT 2 (cont.)

Coke pellet plant
    Sparrows Pt., 500 tons/day, joint venture.
Coal Gasification
    United Kingdom, pilot plant, Republic a participant.

Iron Making

Blast furnaces
    Gary—8000 ton/day—U.S. Steel, recently started.
    Sparrows Pt., Md.—8000 ton/day, Bethlehem Steel Corp. replaces four small furnaces.
    Nanticoke, Ont.—4000 tons/day (est.) Stelco.
Scrap melter
    Burns Harbor, Bethlehem, tentative.
Direct reduction
    Venezuela, Lukens, part owner of FIOR plant.
    Steep Rock, Ont., American participation likely in proposed plant.

Steelmaking

Basic Oxygen Vessels
    Burns Harbor—added vessel, 1 million tons, Bethlehem.
    Sharon, Pa.—added vessel, $10 million, Sharon.
    Indiana Harbor—2.2 million tons, two 210 ton vessel, Inland. Near completion.
    Nanticoke, Ont.—1.3 million tons, Stelco.
    Aliquippa, Pa.—expansion—Jones & Laughlin.
    Youngstown—2.5 million tons, two 200-ton-Youngstown.
    Natrona, Pa.—Improved BOF—Allegheny Ludlum.
Q-BOP
    Fairfield, Ala.—U.S. Steel.
Electric furnaces
    South Works—100 ton—U.S. Steel.
    Fairless Works—Two—U.S. Steel, recently started.
    Baytown, Tex.—Two, U.S. Steel.
    Canton, O.—$28 million modernization plus $6 million for duplexing vessel—Republic.
    Cartersville, Ga.—Two—Atlantic Stee.

Continuous Casting

Blooms — Fairless, U.S. Steel, twostrand, recently started.
Slabs — Baytown, Tex., U.S. Steel, two machines.
Slabs — Nanticoke, Ont., two-strand, Stelco.
Slabs — Great Lakes, 1.2 million tons, National.
Billets — Cartersville, Ga., Atlantic Steel.

Rolling and Finishing

Plate mill — Burns Harbor, 110 in. Bethlehem.
Cold mill — Burns Harbor, 54 in. Bethlemen.
Cold mill — Weirton, National, fully continuous.
Hot strip mill — Nanticoke, Ont., Stelco, 1977.

EXHIBIT 2 (cont.)

Hot strip mill — Granite City, enlargement, National.
Strip mill — Fontana, Kaiser — automatic roll charge.
Blooming mill — Sterling, Ill. Northwestern, 46 in.
Blooming mill — Aliquippa, Pa., Jones & Laughlin.
Bar mill — Sterling, Ill., Northwestern, 14 in.
Bar mill — Cartersville, Ga., Atlantic Steel.
Rod mill — Cuyahoga, O., Modernization—U.S. Steel.
Pipe mill — 100,000 tons, National.
Pipe Finishing — Aliquippa, Pa., Jones & Laughlin.
Anneal and galvanize — Burns Harbor — Bethlehem.
Annealing furnace — Canton, O., Republic.
Scarfer & Shear — Peoria, Ill., Keystone.
Coiler, reheating furnace — Riverdale, Ill., Interlake.
Soaking pits — Brackenridge, Pa., Allegheny Ludlum, seven.
Slab conditioning — Brackenridge, Pa., Allegheny Ludlum 20 percent increase.
Anneal and Pickle — Brackenridge, Pa., Allegheny Ludlum, modernization.
Heat treating — Warren, O., Copperweld, 25 pct expansion.

Source: Iron and Steel Engineer, November, 1974.

was continuing to increase its penetration into the western steel market, undercutting domestic prices by $30 to $40/ton with the local industry gasping for enough business to survive. In 1972, foreign steel took 37% of the western market and 50 to 60% of the entire market for some specific products. This was twice the national average for imports' share of the market.

In 1973 foreign steel producers began finding it more profitable to sell elsewhere and were changing their product mixes as well, so that when these factors were added to long shipping distance and lead times, the product distortions and impending shortages in the marketplace were becoming increasingly evident. Then came the sharp upward demand in the western steel market. Combined with the downturn in steel imports—demand was growing all over the world—the booming western market resulted in shipments by western producers of 5½ million tons in 1973—an all-time high. Customers were asking for more steel than could be produced. They are still asking for more than the area can produce and probably received more steel from western suppliers last year than can be shipped to them this year.

Steel is in short supply in the world today. It is short in the U.S., and perhaps the tightest steel market of all is in the west. Those involved in the western steel industry have an opportunity as never before to break out of that circle and supply the western customers with more steel made in the west.

Western producers have fairly consistently supplied between 50 and 60% of the western market. The remainder comes from eastern mills and imports. But the percentage of the western market supplied by eastern mills has been

declining as the foreign steelmakers increased their share of the market until 1973. In 1973 the foreign steelmakers decreased the share of the western market. The western and the eastern mills combined to take up the slack. Even so, supply fell short of requirements. If the western or the eastern mills, or the overseas producers has more steel to sell in the west today, the market would absorb it. And the demand for steel in the west is going to grow.

As a result of a better outlook in recent months, some expansion plans have been announced in the U.S. In the west, U.S. Steel has announced a 500,000 ton increase for Geneva; Ameron, in Etiwanda, a 350,000 ton expansion; Oregon Steel Mills in Portland, 200,000 tons; and Kaiser will add 200,000 tons of capacity at Fontana. There is also a newcomer to the steel production industry, Schnitzer, in Portland, who has announced plans for an electric furnace-continuous casting shop. (There may be other plans, which have not been as yet formally announced.) Some of these announced programs involve new equipment, and some are based on rounding out facilities to more fully utilize existing melting capacity. Certainly, this is nowhere near enough to meet demand, but it will help.

The foreign steelmakers have traditionally taken a larger portion of the western market than they have of the U.S. market as a whole. In 1972 they peaked at 37%. In 1973 they obtained about 28% of the business. Right now the foreign steelmakers do not really want to do business in the west. What business they are engaged in is strictly to keep their customers' business long term—and they are charging premium prices. Given that kind of situation, American steel could compete with the imports in the west and win back a portion of the western market that the imports now hold.

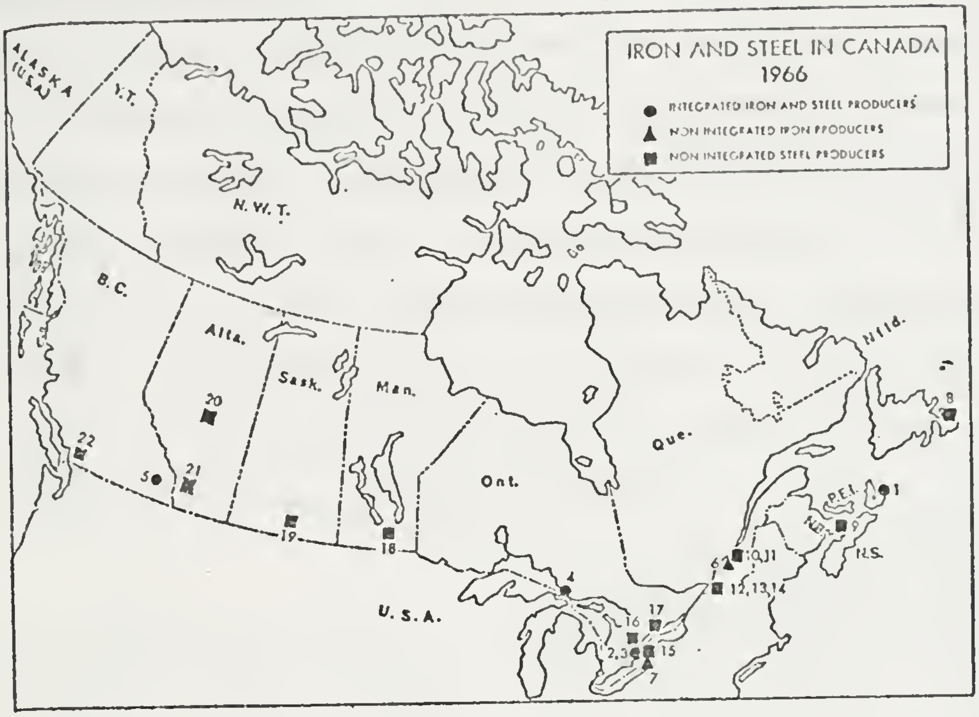
Right now, foreign steelmakers are taking about 28% of the market, or about 2½ million tons. If they hold their share of the western market (roughly 30%) by 1980 they will be selling almost 1 million tons additional in the west than they are today.

If western producers are to maintain their share of their own market, about 1.6 million tons of raw steel capacity must be added. But here is where the real opportunity lies. There is no reason why the west should get twice the percentage of imports that the country gets as a whole. If the imports can be reduced in the western market to 15%, the west will need another 2.6 million tons of steelmaking capacity. Now that means that to reduce imports in the west would need to add 4.2 million tons of capacity. This would provide a fantastic opportunity for people in the steel industry. This would be more than the total output of a Geneva or a Fontana, and almost as much as the two combined. This would mean about 850 more first line foremen, 135 general foremen, about 100 more assistants and mill superintendents, 135 engineers, nearly 100 chemists and metallurgists, plus all of the other necessary disciplines--production planning, environmental control scientists, purchasing, accounting, sales, industrial relations and others. Recruiting, training and developing the people to fill these jobs would be as important and difficult a task as raising the money for the expansion.

The Canadian market was not included in the analysis for two reasons. First, there are a number of Western Canadian mills which are close to the U.S. border. Exhibit 3 shows these. These mills will be very competitive. It was therefore assumed that no significant Canadian market is available to a Montana merchant mill. Secondly, Canada has had a $6-7/ton tariff in the past. This is about 6-8% ad valorem on rolling mill products.

EXHIBIT 3

IRON AND STEEL IN CANADA



Source: Department of Energy, Mines and Resources, Primary Iron and Steel, Jan. 1967, Operators List, Part 1.

INDEX — Iron and Steel in Canada 1966

Integrated iron and steel producers ●

1. Dosco Steel Limited (Sydney)
2. Dominion Foundries and Steel, Limited (Hamilton)
3. The Steel Company of Canada, Limited (Hamilton)
4. The Algoma Steel Corporation, Limited (Sault Ste. Marie)
5. Cominco Ltd. (Kimberley)

Non-integrated iron producers ▲

6. Quebec Iron and Titanium Corporation (Tracy)
7. Canadian Furnace Division of Algoma (Port Colborne)

Non-integrated steel producers (partial listing) ■

8. Newfoundland Steel Company Limited (Octagon Pond)
9. Enamel & Heating Products, Limited (Amherst)
10. Atlas Steels Company (Tracy)
11. Crucible Steel of Canada Ltd. (Sorel)
12. Canadian Steel Foundries Division (Montreal)
13. Canadian Steel Wheel Limited (Montreal)
14. Dosco Steel Limited (Montreal)
15. Atlas Steels Company (Welland)
16. Burlington Steel Co. (Hamilton)
17. Lake Ontario Steel Co. Ltd. (Whitby)
18. Manitoba Rolling Mill Div.(Selkirk)
19. Interprovincial Steel & Pipe Corporation Ltd. (Regina)
20. Premier Works of STELCO (Edmonton)
21. Western Canada Steel Limited (Calgary) (plant leased from Western Rolling Mills Ltd.)
22. Western Canada Steel Ltd. (Vancouver)

III. RESOURCES

North American Iron Ore

Exhibit 4 shows a summary of North American iron ore production. The majority of mines/plants produce in excess of 1 million tons of final product of approximately 65% grade. The product is usually shipped by rail/boat to the consumption destination. The mines are often considerable distances from the steel mills. Exhibit 5 shows typical distances between origin and destination for iron ore shipped by rail for various U.S. operations. The only five mines in the Mountain States region are in Utah and Wyoming. They have the following distances and yearly productions:

Mine	Destination	Approx. Miles	Million Tons Production Yearly
Comstock Mine, Cedar City, Utah	Pueblo, Col.	815	.93
Desert Mound Mines, Cedar City, Utah	Provo, Utah	260	.53
Iron Springs Mine, Cedar City, Utah	Provo, Utah	260	.50
Sunrise Mine, Sunrise, Wyoming	Pueblo, Col.	300	.54
Atlantic City Ore, Landers, Wyoming	Provo, Utah	350	1.70

Western U.S. Coal Supply

Most coal and iron ore mines are owned by the steel companies that use the product. The principal coking coal deposits in the Rocky Mountain area are held by steel-producing interests that maintain a strong reserve position and captive mines for their coke supply. The remaining (and available) coking coal reserves are in relatively small deposits, hard-to-mine seams, or are the remnant areas of old shut-down mining districts. They are "problem children" and are economically marginal at best.

In recent years the requirement for high-strength coke for blast-furnace charges has led to the practice of blending several coals of medium coking

EXHIBIT 4

NORTH AMERICAN IRON ORE PRODUCTION

Name of Operation/ Location	Start Up	Ore Grade (ave.%)	Ore Miner- als	Conc. Output (long tons per day)	Pellets (long tons per day)	'74 Projected (long tons per year)	% Grade Final Product	Ship- ping Methods	Expansion Under way? Completed?
United States									
Arcturus mine Marble, Minn.	na	na	hem	-	-	na	na	rail	no;no
Black River Falls mine Black River Falls, Wisc.	1969	33	mag	3,000	3,000	940,000	64.75	rail	no;no
Butler Taconite Nashwauk, Minn.	1967	21.8	mag	7,100	8,000	2,626,000	66.1	rail, boat	no;yes
Canisteo mine Coleraine, Minn.	1933	38.10	goe, hem	8,100	-	1,200,000	56	rail	no;no
Cedar City mine Cedar City, Utah	1946	39.8	mag, hem	4,000	-	na	na	na	na
Comstock mine Cedar City Utah	1953	51.92	hem, mag	-	-	950,000	51.92	rail	no;no
Coons Pacific Eveleth, Minn.	1950	-	hem	9,500	-	na	-	rail, boat	no;no
Eagle Mountain mine Eagle Mountain, Calif.	1948	34	hem, mag	18,000	6,500	3,791,000	61	rail	no;no
Empire Iron Mining Co. Ishpeming, Mich.	1964	33	mag	16,920	10,085	4,060,000	64.65	rail, boat	no;yes
Erie Mining Co. Hoyt Lakes, Minn.	1957	32	mag	29,500	29,100	10,600,000	62.5	rail, boat	no;no
Eveleth Expansion Co. Eveleth, Minn.	1976	na	mag	na	na	na	na	rail	yes;no

EXHIBIT 4 (cont.)

Name of Operation/ Location	Start Up	Ore Grade (ave.%)	Ore Minerals	Conc. Output (long tons per day)	Pellets (long tons per day)	'74 Projected (long tons per year)	% Grade Final Product	Shipping Methods	Expansion Under way? Completed?
Eveleth Taconite Co. Eveleth, Minn.	1965	23.5	mag	5,567	5,700	2,300,000	64.4	rail	no;no
Grace mine Morgantown, Pa.	1958	41.75	mag, chalc	4,900	4,900	1,160,700	65.4	rail	yes;yes
Gross-Nelson mine Eveleth, Minn.	1966	48	hem	3,600	-	300,000	54	rail, boat	no;no
Groveland mine Randville, Mich.	1959	35	hem, mag	5,850	6,000	2,045,000	63	rail, boat	no;no
Hill Annex mine Calumet, Minn.	1917	36.55	goe, hem,lim	6,000	-	940,000	58	rail, boat	no;no
Hull-Rust mine Hibbing, Minn.	1965	58	hem	3,200	-	150,000	54	rail, boat	no;no
Jackson County Iron Co. Black River Falls, Wisc.	1969	36	mag	2,700	na	920,000	64.91	rail	no;no
Lind-Greenway mine Grand Rapids, Minn.	1953	30	goe, hem,lim	5,800	-	918,000	58.70	rail, boat	no;no
Lone Star Steel Co. Lone Star, Tex.	1947	26.68	lim, sid	3,821	-	na	52.60	rail	no;no
Luck Mining Co. Silver City, N.M.	1938	43	hem	none	-	40,000	43	rail	no;no
MacIntyre Development Tahawus, N.Y.	1942	28	mag	1,000	-	261,000 (gt)	62-64	rail, truck	no;no
Mather mine Ishpeming, Mich.	1943	54.69	hem, mar	-	-	1,954,000	60.22	rail	no;no

EXHIBIT 4 (cont.)

Name of Operation/ Location	Start Up	Ore Grade (ave.%)	Ore Miner-als	Conc. Output (long tons per day)	Pellets (long tons per day)	'74 Projected (long tons per year)	% Grade Final Product	Ship-ping Methods	Expansion Under way? Completed?
Desert Mound mine Cedar City, Utah	1951	50	-	-	-	530,000	-	rail	none
Atlantic City Ore Lander, Wyo.	1962	26	na	5,000	5,000	1,700,000	62.4	rail	none
McKinley mine McKinley, Minn.	1968	56.5	goe, hem, lim	12,000	-	2,240,000	60	rail, boat	no;no
Meramec Mining Co. Sullivan, Mo.	1961	45	mag	5,500	4,800	na	67	rail	no;no
Minntac Plant Mt. Iron, Minn.	1967	22	mag	35,000	35,000	12,500,000	65.3	rail, boat	yes;no
National Steel Pellet Plant Keewatin, Minn.	1967	31	mag	7,200	7,740	2,600,000	65.7	rail, boat	yes;no
Nevada-Barth Corp. Carlin, Nev.	1960	60	hem, mag	none	-	105,000	60	rail	no;no
Pilot Knob Pellet Co. Ironton, Mo.	1968	34.6	mag	5,616	4,080	950,000	63.46	rail	yes;no
Pioneer Pellet Plant Ishpeming, Mich.	1965	-	hem, mar	4,800	4,616	1,550,000	61.5	rail, boat	no;no
Plummer mine Coleraine, Minn.	na	na	hem	na	-	na	59.9	rail, boat	no;no
Republic mine Ishpeming, Mich.	1956	36	hem, mag	10,400	na	2,610,000	65.2	rail, boat	no;no
Neville mine Chisholm, Minn.	1974	na	hem	na	-	200,000	na	rail	no;no

EXHIBIT 4 (cont.)

Name of Operation/ Location	Start Up	Ore Grade (ave.%)	Ore Minerals	Conc. Output (long tons per day)	Pellets (long tons per day)	'74 Projected (long tons per year)	% Grade Final Product	Shipping Methods	Expansion Under way? Completed?
New York Division Star Lake, N.Y.	1944	23.2	mag, mar	2,730	-	943,000	65.2	rail	no;no
Rana mine Kinney, Minn.	1974	58	hem	2,400	-	100,000	52	rail, boat	no;no
Reserve Mining Co. Silver Bay, Minn.	1955	24	mag	28,500	29,500	10,491,583	60.76	boat	no;yes
Rouchleau group Virginia, Minn.	1943	na	hem, lim	na	-	na	58.17	rail, boat	no;no
Sherman mine Chisholm, Minn.	1948	na	hem, lim	na	-	na	59.18	rail, boat	no;no
Sherwood mine Iron River, Mich.	1940	54.7	goe, hem	na	-	385,000	55	rail, boat	no;no
Stephens mine Aurora, Minn.	1957	na	na	na	-	na	58.18	rail, boat	no;no
Sunrise mine Sunrise, Wyo.	1900	na	hem	2,400	-	500,000	48.99	rail	no;no
Tilden Mining Co. Ishpeming, Mich.	1974	36	hem	12,300	11,000	none	65.90	rail, boat	no;no
U.S. Pipe & Foundry Co. Russellville, Ala.	1954	48	goe	1,000	na	na	na	rail	no;no
Whitney mine Hibbing, Minn.	1973	na	goe, hem	13,500	-	700,000	52.6	rail, boat	no;no
Wyoming mine Virginia, Minn.	1960	na	hem	na	-	175,000 (conc.)	na	rail, boat	no;no

EXHIBIT 4 (cont.)

Name of Operation/ Location	Start Up	Ore Grade (ave.%)	Ore Minerals	Conc. Output (long tons per day)	Pellets (long tons per day)	'74 Projected (long tons per year)	% Grade Final Product	Shipping Methods	Expansion Under way? Completed?
Canada									
Adams mine Kirkland Lake, Ont.	1966	19.5	mag	3,400	3,050	1,116,000	65.66	rail	no;no
Algoma Ore division Wawa, Ont.	1939	35	sid, pyr	6,150	-	2,100,000	51	rail	no;no
Caland Ore Co. Atikokan, Ont.	1960	55	goe, hem	na	3,300	1,100,000	64.1	rail, boat	no;no
Griffith mine Red Lake, Ont.	1968	24	mag	4,000	4,000	1,500,000	66.8	rail, boat	no;no
Hilton mines Shawville, Que.	1957	34	mag	2,450	2,450	875,000	67	rail	no;no
Iron Ore Recovery Plant Sudbury, Ont.	1956	-	pyrr	-	2,500	550,000	67	rail	no;no
Iron Ore Co. of Carol Lake project, Labrador City, Nfld.	1962	38.5	hem, mag	59,000	29,000	8,600,000 15,700,000	65	rail, boat	no;yes
Iron Ore Co. of Canada -Schefferville	1954	52	hem, mag	-	-	6,318,000 (nat.ore)	54-55	rail, boat	no;no
Iron Ore Co. of Canada -Seven Islands	1954	-	hem, mag	16,400	16,400	3,500,000	65	rail, boat	no;yes
Marmoraton Mining Co. Marmora, Ont.	1955	28	mag	1,500	1,340	464,000	65	rail, boat	no;no
National Steel Corp. of Canada, Capreol, Ont.	1957	26.5	mag	1,874	1,836	670,000	63.5	rail, boat	no;no

EXHIBIT 4 (cont.)

Name of Operation/ Location	Start Up	Ore Grade (ave.%)	Ore Miner-als	Conc. Output (long tons per day)	Pellets (long tons per day)	'74 Projected (long tons per year)	% Grade Final Product	Ship-ping Methods	Expansion Under way? Completed?
Quebec Cartier Mining Port Cartier, Que.	1959	34.2	hem	24,000	-	8,400,000	66	rail, boat	yes;no
Quebec Iron and Titanium Corp., Sorel, Que.	1949	86	lim	5,000	-	858,000	70	boat, rail	yes;no
Sherman mine Temagami, Ont.	1968	23	mag	3,500	3,400	1,054,000	65.66	rail	no;no
Steep Rock Iron Mines Atikokan, Ont.	1944	59	goe, hem, lim	-	4,350	1,450,000	63.2	rail, boat	no;no
Texada Mines Gillies Bay, B.C.	1952	38	mag, chalc	2,000	-	400,000	65	boat	no;no
Wabush mines Wabush, Lab.-Que.	1965	36	goe, mag	16,200	16,500	5,943,000	65.8	boat	no;no
Westfrob Mines Tasu, B.C.	1967	47.5	mag	1,200 (sinter) 2,000 (pellet)	-	990,000	62 69.5	boat	no;no

Source: Engineering and Mining Journal, November, 1974.

EXHIBIT 5

DISTANCES OF IRON ORE SHIPMENTS BY RAIL

From	To	Distance (miles)
Mesabi	Granite City	700
Gogebic	Granite City	600
Marquette	Granite City	625
Gogebic	Birmingham	1125
Gulf Coast	Chicago	938
Mesabi	Chicago	550
Fillmore County, Minn.	Birmingham	938
Fillmore County	Granite City	450
Gulf Coast	Granite City	688
Gogebic	Escanaba	188
Gulf Coast	Birmingham	250
Schefferville	Sept Iles	357
Iron Mt., Miss.	Birmingham	563
Upper New York	Pittsburgh	563
Fillmore County	Chicago	313
Erie, Pa.*	Sparrows Point	438
Eagle Mountain	Fontana	163
Wyman	Hamilton	332
Baltimore	Middleton	500
Baltimore	Chicago	688
Gogebic	Weirton	844
Gogebic	Pittsburgh	875
Mesabi	Pittsburgh	1000
Lowphos	Depot Harbor	150
Baltimore	Ashland	438
Copper Cliff*	Welland	338
Atikokan	Port Arthur	144
Mesabi	Pittsburgh	1000
Hilton*	Hamilton	281
Mesabi	Cleveland	900
Mormora*	Hamilton	175
Lake Erie	Ashland	250
Copper Cliff*	Sault Ste. Marie	175
Philadelphia	Pittsburgh	288
Gulf Coast	Lone Star	281
Baltimore	Youngstown	300
Steep Rock	Port Arthur	138
Baltimore	Weirton	288
Baltimore	Pittsburgh	218
Mesabi	Duluth	69
Ashtabula	Aliquippa	122
Mormora*	Hamilton	125
Iron Mountain	Granite City	94
Cleveland	Pittsburgh	125
Cleveland	Weirton	119
Ashtabula	Youngstown	63
Ashtabula	Warren	47
Wawa*	Michipicoten	8

Sources: Hanna Mining Company; Canada, Bureau of Mines; *1961.

characteristics to produce an improved high-strength coke. Kaiser Steel formerly brought blending coal from the Oklahoma-Arkansas coal fields, but now obtains this requirement from the Carbondale Field in western Colorado. This mine also supplies U.S. Steel at Provo, Utah, and CF&I Steel at Pueblo, Colorado, with blending coal.

In recent years a few coal companies in the western U.S. had made overtures to the Japanese market with test shipments of blending coal, including several from mines in the Oklahoma-Arkansas district. Those were unsuccessful, as was a shipment from the Somerset Field of Colorado.

In July 1970, on the other hand, Kaiser Steel announced that it had entered a long-term contract for supplying coking coal to the Japanese market. Kaiser will supply 650,000 tpy from the Sunnyside mine in Utah, shipped via Long Beach, Calif. This 10-year contract marks the first export agreement of any appreciable size to be written for a steady long-term supply from the western coking coal regions.

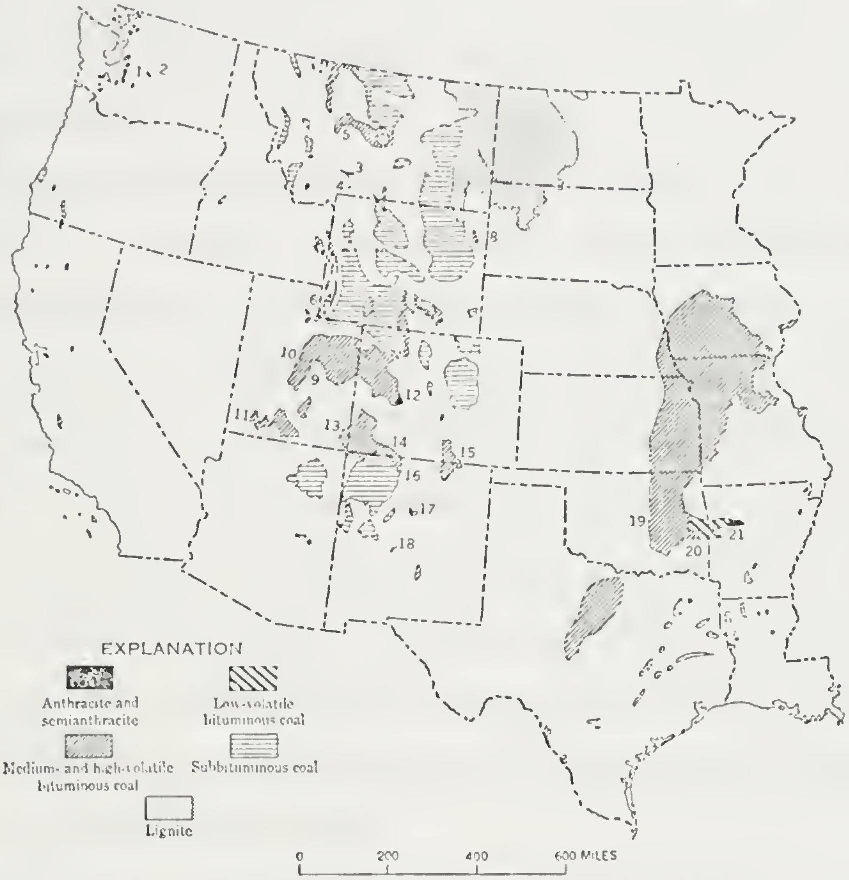
Indeed, coking coal operations in the western United States are essentially an in-house captive mine facility of the aforementioned three steelmaking companies. Of the 21 districts shown on the coking coal map in Exhibit 6, there are few holdings with sufficient reserves that could be acquired by other companies who would like to develop a new coking coal supply of 1 million tons annually over a 15-year period, the usual time and volume commitment.

U.S. Natural Gas Supply

The Federal Power Commission expected the nation's 42 major interstate pipelines to fall short of their contracted deliveries by an average of 11%

EXHIBIT 6

WESTERN U.S. COKING COAL AREAS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21
EXPLANATION
Anthracite and semianthracite
Low-volatile bituminous coal
Medium- and high-volatile bituminous coal
Subbituminous coal
Lignite
0
200
400
600 MILES

1. Wilkeson-Carbonado field and Fairfax-Montezuma area
2. Roslyn field
3. Livingston field
4. Electric field
5. Great Falls field
6. Kemmerer-Willow Creek field
7. Rock Springs field
8. Cambria field
9. Sunnyside-Castlegate field
10. Mount Pleasant field
11. Kolob field
12. Somerset-Crested Butte-Carbondale region
13. San Juan River field
14. Durango field
15. Raton Mesa region
16. Monero field
17. Cerrillos field
18. Carthage field
19. Henryetta district
20. Southern part of the Oklahoma field
21. Western Arkansas field

Source: Coking Coals of Western United States, Paul Averitt in USGS Bulletin 1222 - G, 1966.

during the winter months of 1974. This estimate was probably conservative. Industrial users are the most vulnerable to cutbacks, followed by commercial users, and finally residential consumers.

Montana will be less seriously affected than most states, but since curtailments to existing customers exist, a large new consumer would find uninterruptible contracts for large quantities to be nonexistent.

Montana Resources

Table 1 shows the major iron ore deposits in Montana. The prevelant iron ore mineral is magnetite. The locations with large reserves (more than 10 million tons) are of most interest because of their long range commercial potential. Preliminary research indicates that some of these deposits are amenable to beneficiation and pelletizing. Additional research is necessary to verify exactly what method of treatment is necessary and practical. The possibility of direct reduction also needs to be investigated more thoroughly. Currently no commercial mining of iron ore is being conducted. The Carter Creek deposit ten miles east of Dillon is under active investigation by an Oregon based steel company which holds mining options on the mineral rights there.

At present there is insufficient information available to determine the economic feasibility of mining Montana iron ore. Before further economic studies can be pursued, it is necessary to conduct much more detailed testing of the deposits. If the Montana deposits do not prove to be economical, then the possibility of obtaining ore from existing Canadian, Wyoming, or Utah sources would need to be pursued. Appendix A-1 is a map showing the location of the iron occurrences summarized in Table 1.

TABLE 1

SUMMARY OF MONTANA IRON ORE DEPOSITS

Deposit	Iron Content (from Samples)	Estimated Reserves (millions of tons)	Suitability For Steel Mfg.
Beaverhead/Madison Area			
Carter Creek	30% to 37%	42 to sev.hun.	Can concentrate by normal means-high silica content
Kelly		10+	
Ramshorn		10+	
Dry Boulder Creek		10+	
Johnny Gulch	42%	10+	Difficult separation, high silica
Birch Creek	60% to 70%		
Little Belt Mountains Area			
Running Wolf	53% to 60%	.6 to 1.3++	Has produced commercial ore
Thunder Mountain	55%	.1	
Iron Mountain	55% to 56%	.1+	
Yogo Peak			
Sheep Creek	30% to 53%	5 to 10	Sulpher content may be problem; also silica & phosphorus high
Camas Creek	Unknown	huge	Questionable because of amphibole & pyroxene
Anaconda Area			
Cable Mountain			
Southern Cross	30% to 50%	2 to 3	Can concentrate by normal means
Other Areas			
Sweetgrass Hills	60%		
Elkhorn Mountains	53% to 69%	several +	
Iron Cross Mine	42% to 44%		Have mined for cement; high Titanium
Castle Mountains	32% to 61%	small	
Choteau & Glacier Co.	10% to 55%		Unsuitable due to Titanium
Stillwater Complex	Unknown		Chromite content may be suitable for stainless steel
Anaconda Company Slag Dumps			
Anaconda	45%	40	Considered for use in an integrated steel plant utilizing natural ore & slag by Webb Knapp Inc. in 1959
East Helena	45%	40	
Great Falls	45%	40	

Sources: "Iron Deposits in Montana", Montana Bureau of Mines & Geology, 1956.
"Mineral and Water Resources of Montana", U.S. Geological Survey in collaboration with the Montana Bureau of Mines & Geology, 1963.

Appendix A-2 is a map showing Montana coal occurrences. To date no suitable coking coal source has been established in the State. The suitability of Montana coal for direct reduction has not been established and is extremely doubtful. The use of Montana coal for blending or for use in formed coke production is also questionable at the present time. Coal gasification potential is also a remote unresolved possibility.

The overall coal supply for use in steelmaking within Montana is therefore nonexistent at present. The use of developing coal technology seems to be the only possible hope. With existing sources and technology the only alternative appears to be shipment of coal from out-of-state sources. These sources are considerable distances and competition for the available supply is high.

Suitable limestone and dolomite are plentiful in Montana. Appendix Map A-3 shows the location of the occurrences as well as the type. Processing of the rock into lime will be necessary before electric furnace consumption.

Montana has many of the alloy elements used in steel. Such minerals as nickel, manganese, tungsten, chromium, molybdenum, and vanadium are found in deposits around the State. However, these additives only amount to about 1% of the raw material tonnage. Therefore, the expense of shipping them from out-of-state is not a major cost consideration. These ores may also need concentration or refining before they could be used.

Water availability is shown in appendices A-4 and A-5. It appears that a number of locations could support the water requirements of an iron ore beneficiation plant and a small steel mill. A large steel mill would be feasible only in limited areas.

Montana Railroads, Highways, Utilities, and Services

The Burlington Northern Railway Company is the principal railroad company in the State. East-West connections are especially good, while southbound connections are more difficult. Appendix A-7 shows the routes.

Interstate highways as well as other U.S. and State roads are adequate for truck shipments in all directions. Appendix A-8 shows the major highways in the State.

Appendix A-9 contains the electric and gas system of Montana. Additional power and gas transmission lines would probably be needed to support the mill unless it were located close to the generation points. The availability of uninterrupted service for a steel mill is questionable in Montana. The current hearings on Coalstrip 3 and 4 would greatly affect electricity availability.

About 70% of Montana's natural gas comes from Canada. Recently Canada has not only increased the cost 700% in two years; but, has announced that the supply will be reduced drastically. The power and gas situations are therefore uncertain and discouraging.

The availability and price of natural gas are especially critical with regard to the development of direct reduction facilities. The availability and price of electricity are most critical to the electric furnace where the power cost is usually about 3.2% of the cost of the final product.

The ancillary services needed to support a large industrial operation would be located mainly in the Butte-Anaconda area or the Great Falls area because of their present primary metals operations. Billings and Missoula would have some of the facilities needed. These larger population centers

would also be desirable locations because of their potential manpower pools. In addition, community objections would be minimized because of the present industrial/commercial activity. Locating in these areas would also minimize undesirable sociological and environmental affects.

Stainless Steel Alloys

If stainless steel were to be a major product produced by a Montana steel mill, then the chromium and nickel raw materials are much more significant. A typical stainless steel contains as much as 18% chromium and 8% nickel. Shipping costs would be significant with this volume.

The Anaconda Company controls claims on chromite deposits located south of Columbus, Montana. Recent correspondence with company representatives indicates that no accurate feasibility or cost of utilizing these deposits have been made since World War II. One rough estimate is that the ore could be profitably mined if prices were in the range of $80/ton. Recent chromite prices were about $50/ton.

Domestic mine production of chromite ceased in 1961, although eleven U.S. plants process the chromite. These plants are principally in Ohio, New York and the South. Japan, Sweden, and South Africa are the major import sources of processed ferro-chromium. The principal mine locations in the world are in the U.S.S.R., Turkey, Rhodesia, South Africa, and the Philippines. The price of chromite and/or ferro-chromium could sky-rocket in the future because of this import situation.

IV. PROCESSING OF RAW MATERIALS

Economics of Iron Ore Development

The swift spread of radically different practices in ore mining preparation, and transport have brought about complex changes in the scale and location patterns of activities. In the past, it has been the spatial distribution of blast furnaces that affords the major control over the geography of iron ore demands. The level and location of ore demands are primarily determined by this fact.

Exhibit 7 shows an outline of some of the major considerations involved in iron ore development.

Comprehensive studies must precede commercial beneficiation of iron ores by any process, particularly nonmagnetic iron ores, because of the multiple costs involved and the narrow margin of profit for any method used. Thus, in the reduction roasting and magnetic separation process, crushing and grinding, roasting, and agglomeration of concentrates are major costs. In flotation, grinding, chemical reagents, and agglomeration of concentrates are major costs. Of course, mining itself is a major cost connected with either method of recovery inasmuch as 2 to 4 tons of ore, depending on the natural iron grade, are required to produce one ton of concentrate.

The grade of the ore is far from being the only factor of importance in assessing the value of an ore. Its physical texture and the nature and proportion of impurities (silica, alumina, magnesia, lime, sulfur, and phosphorus, vanadium, zinc, copper, and arsenic) are of vital importance. Physical texture affects mining and preparation costs. Blast furnace

EXHIBIT 7

ECONOMICS OF IRON ORE DEVELOPMENT CHECKLIST

- I. RESERVES — Exploration Drilling and Geological Interpretations
  - A. Quality
    - 1. Natural Fe
    - 2. Deleterious elements
    - 3. Moisture and volatile
    - 4. Concentratability
      - a. Grindability
      - b. Separatability — Oxides or complex silicates, carbonates
  - B. Quantity
    - 1. Tonnage of crude ore
    - 2. Volume of waste material

- II. MINING PLAN
  - A. Development Drilling
  - B. Stripping
    - 1. Overburden — glacial and sedimentary till
— rock
    - 2. Drilling and blasting
    - 3. Shovels and haulage
  - C. Production
    - 1. Drilling and blasting
    - 2. Ore production
      - a. Shovels
      - b. Haulage — trucks
— rail
    - 3. Lean ore
      - a. Shovels, haulage, stocking
    - 4. General
      - a. Access roads
      - b. Drainage
      - c. Service Facilities
      - d. Power costs

- III. BENEFICIATION PLAN
  - A. Crushing and screening
  - B. Grinding
  - C. Separation — classifiers, cyclones, fine screening, magnetic separation, spirals, flotation, thickeners
  - D. Waste disposal
  - E. Agglomeration
  - F. General
    - 1. Material handling
      - a. Mechanical conveyors
      - b. Hydraulic — pumps and piping
    - 2. Water availability and costs
    - 3. Power availability and costs
    - 4. Thermal availability and costs

EXHIBIT 7 (cont.)

IV. TRANSPORTATION

- A. Product stocking and load-out
- B. Rail availability and costs (tariffs)
- C. Pipeline potentials and costs

V. SOCIOLOGICAL COSTS

- A. Townsites
  - 1. Housing
  - 2. Services — roads, utilities, recreation
- B. Taxes
  - 1. Local
  - 2. State
  - 3. National
- C. Environmental Aspects
  - 1. Pollution
    - a. Air
    - b. Water
    - c. Sound — blasting, crushing, etc.
  - 2. Surface Reclamation
    - a. Back fill and/or grading
    - b. Revegetation

efficiency is affected also. Most impurities have to be removed. The oxidation of these impurities and the production of molten slag requires a great deal of heat.

The geological aspects of an ore appraisal must rest on a series of plausible assumptions concerning the underground geology of the district containing the deposit. Some of the assumptions are liable to be proved inaccurate in the event of fuller exploration and prospecting. However skillfully a geologist performs his task in estimating iron ore reserves, even from a purely geological viewpoint, at the end of his search only a rough estimate qualified by many uncertainties can possibly be produced. The margin of error inherent in a preliminary geological investigation is too great for a mining company, which will always insist on a series of mining tests and more positive information before it commits itself to an investment in mining plant, transport facilities, and the like. Such tests are costly and can only be justified by the intention of a mining company to initiate exploration.

Based on the market price for ore and existing freight rates, it is possible to suggest the range of prices that the ore will command at the mine. This would then indicate the maximum level of costs that the mining venture must be below in order to show some profit.

Iron Ore Beneficiation

The purpose of iron ore beneficiation is to: a) increase the present iron content, b) remove impurities, c) promote self fluxing, and d) to alter the physical properties such as particle size and porosity. Most ore preparation takes place close to the mining area unless the cost of energy is excessive there.

The consumption of coke in producing pig iron depends on the quality of the iron ore. The higher the grade of ore, the less coke is needed. Since coal availability and costs are becoming increasingly critical, this reduction is important. Proper beneficiation also promotes blast furnace productivity. Shipping tonnages and costs are also reduced since 1.5 tons of ore are reduced to one ton of pellets. The haulage is physically easier also. Pellet quality doesn't degrade during shipping and storage as ore does. Also, pellets don't freeze together in the winter because of their low water content.

Exhibit 8 shows the existing U.S. and Canadian pellet plants. Exhibit 9 shows additional plants that are under construction.

The average plant produces 3 million tons per year. The smallest plants are slightly under 1 million tons per year. Investment costs are presently in the range of \$45-\$50/ton of annual output. The energy requirements are .5 to 1 million BTU per long ton of fuel heat plus 16-22 kwhr. of electricity. The pelletizing energy consumption ratio is roughly 1 to 10 in comparison with direct reduction. Pelleting plants do not require as much energy to produce the 65% grade final product as the direct reduction processes require to produce its 90% plus grade product.

Direct Reduction

Direct reduction is an alternate processing method. Exhibit 10 classifies the direct reduction processes. The two main methods are: 1) reducing by coal and 2) reducing with natural gas. These processes require from 12-15 million BTU per net ton along with considerable electrical power, (35-122 kwh/net ton). This means about 12-15 thousand cubic feet of natural

EXHIBIT 8

CONTINENTAL PELLETIZING CAPACITY

	Location	Ore	Capacity (million ltpy)
Erie Mining Co.	Minn.	M	10.3
Reserve Mining Co.	Minn.	M	10.8
U.S. Steel Corp. (Minntac)	Minn.	M	12.0
Butler Taconite	Minn.	M	2.6
National Steel Pellet Plant	Minn.	M	2.8
Eveleth Taconite Co.	Minn.	M	2.4
Hanna Mining Co.-Groveland	Mich.	M-H	2.1
Marquette Iron Mining Co.-Republic	Mich.	H	2.5
Humboldt Mining Co.	Mich.	H	0.9
Pioneer Pellet Plant	Mich.	H-Ma	1.6
Empire Iron Mining Co.	Mich.	M	3.5
Meramec Mining Co.	Mo.	M	1.8
Pilot Knob Mining Co.	Mo.	M	1.0
Jackson County Iron Co.	Wis.	M	0.75
Bethlehem Steel Corp.-Grace	Pa.	M	1.5
Cities Service Co.	Tenn.	P	0.9
Kaiser Steel Corp.	Cal.	M-H	2.8
U.S. Steel Corp.-Atlantic City	Wyo.	M	1.5
Total U.S.			61.75
Iron Ore Co. of Canada-Carol	Nfld.	H-M	10.0
Iron Ore Co. of Canada-Sept. Iles	Que.	H-L-G	6.0
Wabush Mines	Que.	H-M	6.0
Steep Rock Iron Mines Ltd.	Ont.	G-H	1.0
Caland Ore Co. Ltd.	Ont.	G-H	1.2
National Steel Co. of Canada	Ont.	M	0.65
Hilton Mine	Que.	M	0.87
International Nickel Co. of Canada	Ont.	P	0.8
Marmoraton Mining Co.	Ont.	M	0.45
Griffith mine	Ont.	M	1.5
Sherman mine	Ont.	M	1.1
Adams mine	Ont.	M	1.1
Total Canada			30.67
Las Encinas SA (Alzada, Col.)	Mexico	M	1.1
Total North America			93.52

Legend: M - magnetite; H - hematite; Ma - marlite; G - goethite; L - limonite; P - pyrite or pyrrhotite.

Source: Engineering and Mining Journal, November, 1974.

EXHIBIT 9

NEW OXIDE IRON ORE PELLETIZING PLANTS UNDER CONSTRUCTION

	Location	Investment (million$)	Start Up	Capacity (million ltpy)
Inland Steel Co. (Minorca)	Minn.	$ 90	1978	2.6
Minntac (U.S.Steel Corp.)	Minn.	200	1978	6.0
Eveleth Taconite Co.	Minn.	150	1976	3.6
Hibbing Taconite Co.	Minn.	150	1976	5.4
National Steel Pellet Plant	Minn.	150	1977	4.2
Total Minnesota		$740		21.8
Tilden Mining Co.	Mich.	$190	1974	4.0
Empire Iron Mining Co.	Mich.	67	1975	1.8
Total Michigan		$257		5.8
Altos Hornos de Mexico SA	La Perla, Chih.	$ 10	1974	0.6
Pena Colorada	Manzanillo, Col.	52*	1975	1.5
Fundidora Monterrey SA	Monterrey, N.L.	25	1976	1.5
Sicartsa	Las Truchas	70	1976	2.0
Total Mexico		$157		5.6
Total Expansion		$1,154		33.2

*Engineering and Mining Journal estimate.

Source: Engineering and Mining Journal, November, 1974.

EXHIBIT 10

DIRECT REDUCTION PROCESSES

- Carbon as reducing element (coal)
  - Rotary furnace
    - SL/RN process
  - Shaft furnace
- Hydrocarbon as reducing element (natural gas)
  - Fixed reactor
    - HyL
  - Shaft furnace
    - Midrex
    - Purofer
    - Armco
  - Fluidization plants
    - Nu-Iron (U.S. Steel)
    - Novalfer
    - Esso FIOR
    - H-Iron

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gas is needed to produce one ton of reduced ore. Most plants are in the 30,000 - 500,000 metric tons per year size so tremendous amounts of cheap natural gas are required.

Exhibit 11 shows the location of existing and planned plants. Seven are now in operation or on order in the U.S. and Canada. Five additional plants are under consideration.

Commercial interest in direct reduction has quickened recently due to a combination of factors. The technology has reached a stage where there is evidence that the processes may be economically and technically efficient.

The Armco Steel Corporation at the Houston Works, with 100% of its melting capacity provided by electric furnaces, reports that its direct reduction unit is operating at design capacity and that it is studying the economics of installing similar models at its other steel producing plants. With electric melting capacity, Armco has been badly hit recently by soaring scrap costs. The Armco direct reduction process uses natural gas as a reductant and produces pellets of about 92% metalization. The natural gas consumption with a heating value of 922 BTU/ton averages 13,288 standard cu ft/ton of direct reduced pellets (12.3 x 10^6 BTU/ton with an average pellet output of 43.8 ton/hr.). Electric power consumption is 30 kwhr/ton, power supplied at 440 v, 3-phase 60 Hz. Total steam requirements are 130,000 lb/hr. Water requirements can vary depending on the price and availability. Make-up water, at present, is running about 86.5 cu ft/ton (650 gal). Excluding raw material and financial charges, the conversion cost is $8.24/ton, although the natural gas cost greatly influences this figure. Capital cost for a 300,000 ton per year plant is estimated in the neighborhood of

EXHIBIT 11

NORTH AMERICAN SURVEY -- DIRECT REDUCTION PLANTS FOR IRON ORES

Direct Reduction Plants In Operation and On Order
(as of December 1974)

Location	Status*	Process	Start	Rated Capacity (mtpy)
Armco Steel, Houston, Tex.	A	Armco	1973	330,000
Korf Steel, Georgetown, S.Car.	A	Midrex	1971	350,000
Gilmore Steel, Portland, Ore.	A	Midrex	1969	300,000
Hecla, Casa Grande, Ariz.	B	SL/RN	1975	65,000
Sidbec 1, Contracoeur, Can.	A	Midrex	1973	350,000
Stelco, Bruce Lake, Can.	B	SL/RN	1975	360,000
Sidbec 2, Contracoeur, Can.	B	Midrex	1976	600,000
Direct Reduction Plant Projects Under Consideration (as of December 1974)				
Korf Steel 2, Georgetown, S. Car.	D			500,000
Sovereign Industries, Ariz.	E			400,000
Ipsco, Saskatchewan, Can.	D			420,000
Lasco, Whitby, Can.	E			300,000
Steep Rock, Lake St. Joseph, Can.	E			1,200,000
Govt., Trinidad & Tobago	C			800,000

*Status: A - in operation; B - on order; C - letter of intent; D - advanced planning stage; E - under study.

Source: Engineering and Mining Journal, January, 1975.

$25 million. A complete plant excluding ore yard but including ore process equipment, clarification equipment and cooling towers requires 74,000 sq.ft.

Armco Steel also has been holding talks with numerous steel firms on licensing of their direct reduction process. On an annual basis the major requirement to operate a Montana operation would be as follows:

Annual Energy and Water Requirements for a Direct Reduction Plant
(300,000 Tons of Pellets/Year Output)

Manpower	50-100 men (mining and reduction plant)
Natural gas	3.6×10^9 cu.ft./year
Electricity	9×10^6 kw hr./year (440 V - 3 phase 60 Hz)
Make-Up Water	1.95×10^8 gallons/year (60 CFM)

New Technology to Improve Economics of Iron Ore Beneficiation

Commercialization of the iron ore pelletizing process and construction of large pelletizing plants has over the past 20 years been the most obvious technical advance in iron ore processing. Now, after many years of research and development, direct reduction of iron ore is capturing a growing share of the capital being invested in ore processing plants. Other important research, directed at fuel economization at pelletizing plants and separation of iron from nonmagnetic taconites, may hold the key to future technical breakthroughs by the iron ore industry.

One problem in achieving projected demand for reduced iron ore is the production of pellets or ore of adequate quality to feed direct reduction facilities. Gangue limitations for such plants (SiO_2 + Al_2O_3) fall below 3%, while U.S. pellet production currently averages about 6.6% gangue and Canadian production more than 5%. About 95% of U.S. ore and pellet production is unacceptable for direct reduction. Unless an economic beneficiation

method of reducing these gangue percentages is developed—magnetic, flotation, or otherwise—foreign ores must of necessity provide the major source of feed for future North American direct reduction plants.

Worries over the availability of natural gas for pellet plants have sparked testing of fuel alternatives for concentrates produced in Minnesota, Michigan, western Ontario, Missouri, and elsewhere. There is a very real possibility that natural gas supplies will be inadequate to support budgeted expansion programs, and supplies may well become interruptible for current installed capacity. The obvious solutions lie in Bunker C—now used by pelletizers on the Labrador Trough and Cleveland Cliffs' new Tilden plant, and an alternative option in Missouri—or sub-bituminous coals or lignites of western origin—the Dakotas, Montana and Wyoming.

The future of direct reduction is indeterminate. There are now four direct reduction plants (operating and under construction) in the U.S., whereas most scrap-deficient steelmaking countries do not seem to be in any hurry to install any one of the direct reduction processes. One can only assume that many steelmakers are not yet sufficiently convinced to take on the problems and uncertainties of breaking in new production facilities while they are able to acquire their iron from existing sources. Those plants that are operating have been built to satisfy local conditions that have no other logical or economical solution.

The application of any direct reduction process to a particular iron oxide should be preceded by an extensive test program to develop the operating characteristics and costs. There is not yet sufficient background information available on the processing of a wide variety of iron ores to allow

the design of a commercial plant without a test program. Such a program should develop not only the reduction parameters, but should result in a sufficient quantity of metallized iron for steelmaking tests.

Processing of Other Raw Materials

The three major other raw materials that must be processed are scrap, limestone (and/or dolomite), and coal. Processing of the scrap would not present a problem. Scrap would need to be sorted, cut to useable size, and in some cases compacted. Processing the limestone could also be accomplished. Preparation of the limestone by crushing as well as lime production are both within the capability of the State at present. Coal processing presents a problem since no suitable coking coal fields have yet been developed in the State. The present methods of processing also create serious air pollution problems. A new process called formed coke is under development, however. This new method promises not only to be much cleaner, but also has the potential of using coal that was previously unfit for coking.

Six processes are currently under development. The following exhibit shows these processes:

Processes Under Development

Formed Coke Method	Type of Process
Bergbau Forschung (BBF) Process	Hot char bonded with coking coal
FMC Process	Coal bonded with tar or pitch
Sumitomo Process	Coal bonded with tar or pitch
Consol-BNR Process	Hot char bonded with coking coal
Auscoke (BHP) Process	Coal bonded with tar or pitch
Sapozhnikov Process (USSR)	Coal bonded with pressure alone

After more than 10 years of developmental and pilot plant work, the FMC and Consol-BNR processes give promise of approaching commercial operation. If direct reduction were used, the coking operation would be eliminated.

V. STEEL MILL

Steelmaking: Process Alternatives

Two basic process configurations are likely candidates for a Montana based industry. Each of these alternatives will be explained. The requirements for each configuration will be discussed.

A. The first alternative consists of the following process:

1. Coke plant
2. Blast furnaces
3. BOF*/Continuous Casting Plant
4. Finishing Mills for plate, bars, and sheet

Considerable economics of scale exist with this process choice. The Coke plant/Blast furnace combination requires at least a 1.0 million ton per year output to be competitive. The BOF/Continuous Casting plant needs to be balanced with the capacity of the blast furnace. If another source of hot metal such as direct reduction were used, however, a smaller BOF/Continuous Casting volume would be economical. This scaling down would not adversely affect costs. In addition, the operational simplicity is a distinct advantage for an inexperienced management and labor force.

This process configuration would require approximately the following materials, energy, manpower and investment for one million tons per year output:

Iron ore pellets (tons)	1.27×10^6
Coal (tons)	$.71 \times 10^6$
Lime and Limestone (tons)	$.25 \times 10^6$
Scrap (tons)	$.31 \times 10^6$
Water (gallons)	65×10^9 (17,500 CFM)

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*Basic Oxygen Furnace

Power (kw hrs.)	351×10^6
Natural gas (cubic feet)	6×10^9
Oxygen (tons)	$.07 \times 10^6$
Fuel oil (gallons)	22×10^6
Man power	6000 people
Investments	$735 million

B. The second alternative would consist of:

1. Electric furnace plant
2. Continuous billet casting
3. Merchant bar and rebar mill

This configuration is called a "mini steel mill" and is very common in the U.S. They usually operate in areas where there is a surplus of scrap and electrical power is available and cheap. Most mini mills are privately held and no public accounting is made. Therefore detailed analysis is not possible. However, most are doing relatively well when compared to other steel producers.

This type of plant has a number of advantages. Some of them are:

1. Tight specifications are attainable on finished products. Its outstanding process control allows almost any grade or composition of steel to be made including stainless.
2. Plants with relatively small tonnages are still economical and competitive.

The electric-arc furnace is the most economical steel producing method when:

1. Steel production requirements are insufficient to justify the use of a blast furnace.
2. There is high steel-scrap availability but at a distance from natural sources of coke, limestone, and high grade iron ores.
3. Steel production requirements are intermittent or must be supplied within controlled time limits.

Continuous casting has lower investment and operating costs than alternative processes. This is especially true when small tonnages are being produced. It is also possible to continuous cast stainless steel. Less scrap is produced, (4% vs. 18% with ingots), less space is needed, finished product processing requires less rolling, and quality is at least as good as alternative methods.

Canada has successfully adopted this steelmaking method. The Western Canadian portion of the industry consists of a number of relatively small plants, using scrap metal as a raw material and producing steel mostly in electric furnaces. The rolling mill products of these western plants relect mainly the composition of regional demand—merchant bars, reinforcing bars, light structures, and rods.

Based on a planned output of 150,000 tons per year the yearly requirements of raw materials, energy, manpower, and investment would be:

Scrap (Home)	21,800 tons
Scrap (Purchased)	168,200 tons
Ferro alloys	1,500 tons
Lime	6,600 tons
Fluorspar	260 tons
Coke	1,560 tons
Water Total Make-up	2.55 x 10^9 gallons (656 CFM)
Power	1.2 x 10^8 kw hrs (16,000 KVA peak usage)
Manpower	600 people
Investment	$208/ton of finished product capacity
Total Investment: Fixed assets	$31.265 million
Working Capital	$6.85 million

The electric furnace can use direct reduced ore instead of scrap as its source of iron. Enough prereduced iron has been used in electric arc furnaces to remove any doubt regarding its effectiveness, both in batch feeding and in continuous feeding.

Cost Comparisons

The costs of the two basic steel mill alternatives will now be demonstrated. Exhibit 12 shows the estimated construction costs of a typical mini-mill operation. A comparison with a larger mill is as follows:

	Mini-Mill	Large Mill
Cost/ton	$208/ton of capacity	$735/ton of capacity
Yearly output	150,000 tons	1 million tons min.
Total Facilities Investment	$31.2 million	$735 million min.

The production costs estimates for the two alternatives are shown in Exhibit 13. Because the large plant produces a different product line and mix of products, its sales price/ton is higher.

Preferred Plant

The electric furnace, continuous billet casting and a rolling mill alternative is better adapted to a Montana location than the larger alternative. The major equipment needed is:

Electric Furnaces	Two 40/ton (14-ft diameter) with 16,000 KVA transformers, 2 hr 50 min tap-to-tap cycle.
Continuous Caster	One 2-strand machine.
Merchant Bar & Rebar Mill	One 16-stand continuous mill with one 50-60 tph billet re-heat furnace.

The mill would produce 150,000 tons of common merchant bar and 50,000 tons of reinforcing bar. This is 15% of the market in the Western U.S. regions (excluding California). Exhibit 14 shows a flow diagram of the annual material flow.

There have been more than 40 such works built in the U.S. in the last ten years. These works make a habit of melting by night when power is cheap and rolling by day.

EXHIBIT 12

CONSTRUCTION COST ESTIMATE - MINI MILL

	Thousand Dollars
Material Handling Facilities	$ 635
Electric Furnace Plant	4,445
Continuous Casting	4,191
Bar and Rebar Mill	10,160
General Plant	635
Total Direct Costs	$20,066
Contractor's Field Overhead, Plant and Profit	1,505
Sub Total	$21,571
Engineering, Supervision and Procurement	2,157
Sub Total	$23,728
Contingency	2,373
Total Design and Construction	$26,101
Escalation	3,131
Sub Total	$29,233
Spare Parts	254
Start-up Costs	1,778
Total Project	$31,265

EXHIBIT 13

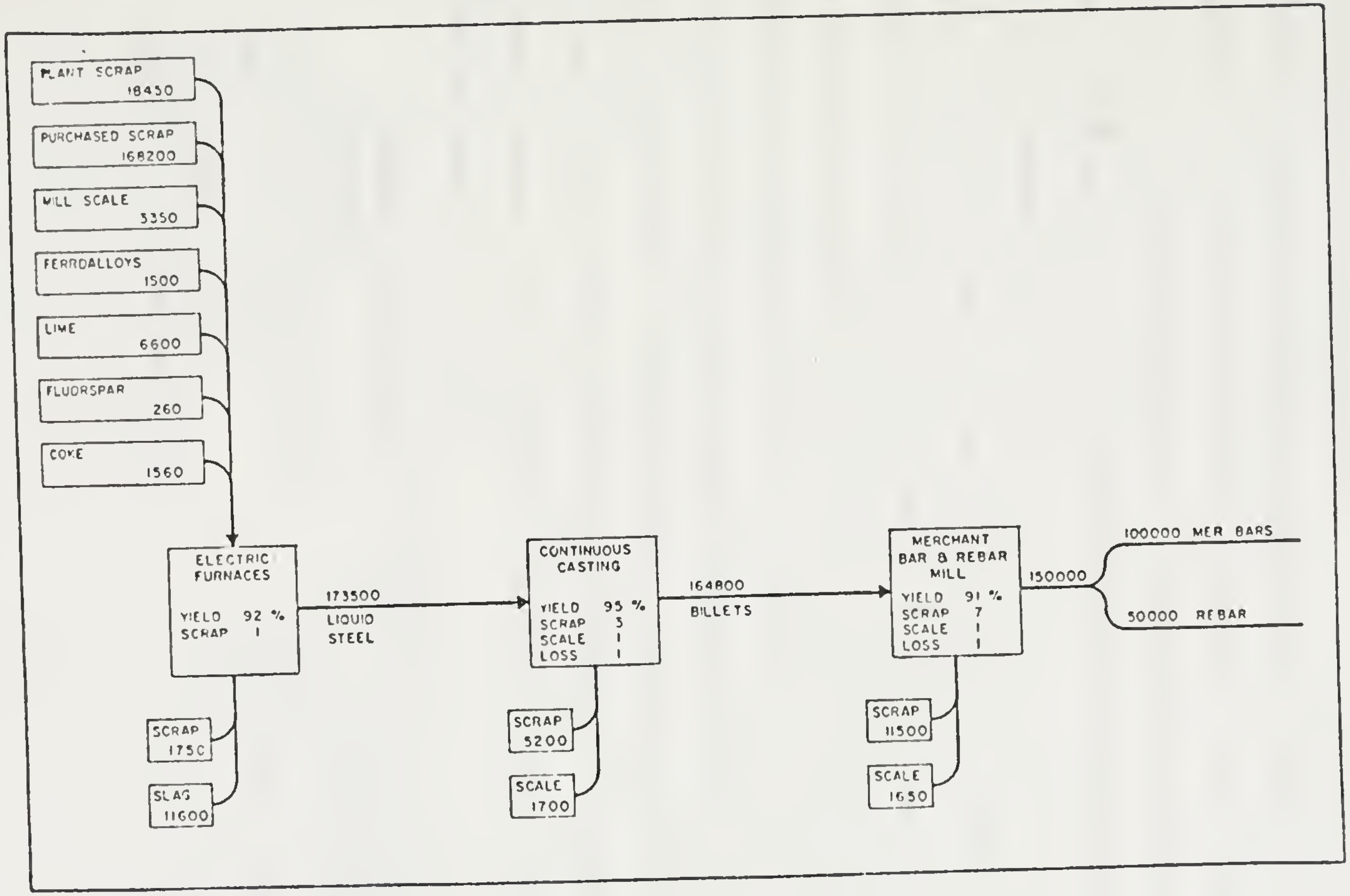
TYPICAL PROCESSING COST SUMMARY

Cost Categories	Mini-Plant		Large Mill	
	$/NT*	%	$/NT*	%
Scrap	$ 37.13	27%	$ 10.00	6%
Pellets			20.50	12.5%
Coke			10.00	6%
Other Materials	1.00	.7%	3.35	2%
Total Material (Delivered)	$ 38.13	27.7%	$ 43.85	26.5%
Electric Furnace Power	4.42	3.2%		
Electric Furnace Processing	13.18	9.6%		
Blast Furnace Processing			6.08	3.7%
Total Liquid Metal Cost (Material & Processing)	$ 55.73	40.5%	$ 49.93	30.2%
Additional Processing	27.44	20.0%	40.17	24.3%
Cost of Manufacturing Finished Steel	$83.17	60.5%	$ 90.00	54.5%
Capital Charges, Profit, Taxes, etc.	$ 46.83	34.0%	$ 65.16	39.5%
Price F.O.B. Plant	$130.00	94.5%	$155.16	94.0%
Freight	7.80	5.5%	9.30	6.0%
Delivered Price including Freight	$137.80	100.0%	$164.46	100.0%

*$/NT = Dollars per net ton of finished product.

EXHIBIT 14

SIMPLIFIED FLOW DIAGRAM, 150,000 TON MINI STEEL PLANT



Source: Journal of Metals, September, 1972.

A major steelworks requires a large number of ancillary workers: such a plant is usually equipped with engineering shops, transport divisions, mobile equipment shops, personnel departments, research and development, canteen and other non-productive staffs. In a small plant, it is almost certain that there will be found many Jacks-of-all-trade turning their hands to anything. It is almost certain that there will be virtually no personnel department, no training department, no research labs, so that on paper it can be expected that a mini-steelworks will have lower non-productive labor costs compared with a large works.

At the bottom of any cost sheet is an item for overheads. It has already been mentioned about the question of overheads on the personnel side, but central research and development, advertising, overseas agents, charitable contributions and items of this nature will also not figure in many of the miniworks devoted to making reinforced concrete bars only for a very limited market. Miniworks based on the local market, with no export, are going to have a lower working capital than their big brother shipping bars long distances. The following table shows a summary of some advantages and disadvantages of a miniworks.

Summary of Advantages and Disadvantages of Miniworks

Advantages	Disadvantages
Uses simple standard equipment	Depends on scrap as raw material
Early return on capital	Sensitive to power costs
Low transport costs	Limited range of products
Flexibility in meeting orders	

Financial Analysis of the Preferred Plant

The anticipated cash flows from the mini-mill are shown in Exhibit 15. Construction costs, spare parts costs and owner's costs were spread over the period of construction, the schedule of which indicated that, with engineering starting in mid-1979 and initial work in the field starting in September of that year, the plant could start operations in mid-1981.

Working capital requirements were estimated to total, when full production was reached, about $6.85 million. The expected start-up curve indicated that only about 22% of annual plant capacity could be produced in the last half of 1981, and this was estimated to be all re-bar; in 1982, production of all products was expected to pick up to 80% of capacity and full production should be reached in 1983. Revenue, production costs and start-up costs were calculated on this basis.

Selling and administrative expenses were estimated to be 10% of sales revenue. Proper allowances were made for property taxes and calculated insurance costs on only about 90% of the valuation of the plant. Depreciation was assumed on an 18-year SOYD basis.

The operating loss in the first year was carried forward and taxes began to be paid in 1983. Payout occurred in 1990, the tenth year of operations and the twelfth year of the project. Allowing no salvage value on the plant after it had been fully depreciated, return on investment was calculated as about 8%.

All cost calculations are based on actual or estimated 1975 prices. Construction and equipment costs were estimated based on historical trends. Operating costs were obtained from current market quotations and established reports on materials, labor, and power.

EXHIBIT 15

TYPICAL CASH FLOW CALCULATIONS FOR MINI-STEEL MILL (Thousands of dollars)

	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
Sales Revenue			4,950	23,400	29,250	29,250	29,250	29,250	29,250	29,250
Production Costs			3,442	14,970	18,712	18,712	18,712	18,712	18,712	18,712
Start-Up Costs			825	1,500	0	0	0	0	0	0
Gross Manufacturing Profit			682	6,930	10,538	10,538	10,538	10,538	10,538	10,538
Selling & Administration			495	2,340	2,925	2,925	2,925	2,925	2,925	2,925
Property Taxes (2.4%)			192	192	192	768	768	768	768	768
Insurance			150	150	150	150	150	150	150	150
Depreciation (SOYD)*			3,265	3,082	2,899	2,715	2,532	2,349	2,166	1,983
Net Earnings Before Tax			(3,420)	1,166	4,372	3,980	4,163	4,346	4,529	4,712
Federal & State Tax (54%)**			0	0	1,144	2,149	2,248	2,349	2,449	2,549
Net Earnings After Tax					3,228	1,831	1,915	1,997	2,080	2,163
Add Back Depreciation			3,265	3,082	2,899	2,715	2,532	2,349	2,166	1,983
Cash Flow from Operation			(155)	4,248	6,127	4,546	4,447	4,346	4,246	4,146
Investments: Fixed Assets	(900)	(21,200)	(9,165)							
Working Capital			(1,200)	(4,000)	(1,650)					
Net Cash Flow	(900)	(21,200)	(10,520)	248	4,477	4,546	4,447	4,346	4,246	4,146
Cumulative Cash Flow	(900)	(22,100)	(32,620)	(32,372)	(27,895)	(23,349)	(18,902)	(14,556)	(10,310)	(6,164)

*SOYD = Sum of the Years Digits method.

**Any applicable Investment Tax Credit would reduce this tax liability.

EXHIBIT 15 (cont.)

TYPICAL CASH FLOW CALCULATIONS FOR MINI-STEEL MILL (Thousands of dollars)

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	Residual
Sales Revenue	29,250	29,250	29,250	29,250	29,250	29,250	29,250	29,250	29,250	29,250	
Production Costs	18,712	18,712	18,712	18,712	18,712	18,712	18,712	18,712	18,712	18,712	
Start-Up Costs	0	0	0	0	0	0	0	0	0	0	
Gross Manufacturing Profit	10,538	10,538	10,538	10,538	10,538	10,538	10,538	10,538	10,538	10,538	
Selling & Administration	2,925	2,925	2,925	2,925	2,925	2,925	2,925	2,925	2,925	2,925	
Property Taxes (2.4%)	768	768	768	768	768	768	768	768	768	768	
Insurance	150	150	150	150	150	150	150	150	150	150	
Depreciation (SOYD)	1,800	1,617	1,434	1,251	1,068	884	701	518	335	152	
Net Earnings Before Tax	4,895	5,078	5,261	5,444	5,627	5,810	5,993	6,176	6,359	6,542	
Federal & State Tax (54%)	2,649	2,749	2,849	2,949	3,049	3,149	3,249	3,349	3,449	3,549	
Net Earnings After Tax	2,246	2,329	2,412	2,495	2,578	2,661	2,744	2,827	2,910	2,993	
Add Back Depreciation	1,800	1,617	1,434	1,251	1,068	884	701	518	335	152	
Cash Flow from Operation	4,046	3,946	3,846	3,746	3,646	3,545	3,445	3,345	3,245	3,145	
Investments: Fixed Assets											
Working Capital											6,850
Net Cash Flow	4,046	3,946	3,846	3,746	3,646	3,545	3,445	3,345	3,245	3,145	
Cumulative Cash Flow	(2,118)	1,828	5,674	9,420	13,066	16,611	20,056	23,401	26,646	29,791	36,641

Payback = 9½ years   Return on investment = 8%

The forecasted economics are based on the relationship of costs as they exist in mid-1975. In the last two years there has been a rapid change in the relationship of costs. Therefore if new relationships emerge, the analysis will need to be up-dated.

Environmental Considerations

Concerning the matter of environmental quality, it is widely accepted in the industry that the generation of emissions can be more easily and economically controlled at the direct reduction (or scrap)/electric furnace combination than at the blast furnace/oxygen converter installation. If the electric furnace arrangement is chosen, this not only promises that there will be minimal effect on the air and water, it also makes the average cost of pollution control smaller. On the average, pollution control adds 8-10% to the cost of processing and adds \$25-\$30/ton of capacity to the investment. With an electric furnace this cost is not as high.

Usually 65% of the intake water must be treated before it is used (filtration, pH adjustment, etc.). A large portion of the water can be used over and over by recirculation. It is usually necessary to treat about 65% of the discharge water to upgrade its quality before it is released. The amount of recirculation that is used depends on the relative cost of reconditioning water for reuse, the cost of discharge treatment, and the amount and quality of water available.

Supporting Services

Steel mill operations require a large number of supporting services. Exhibit 16 shows some of these. These services for the most part are supplied internally. With smaller plants such as mini-mills, many of the

EXHIBIT 16

TYPICAL SUPPORT SERVICES

Steam generation
Truck repair shops (trucks, cranes, dozers, etc.)
Rail repair shops (engines & rolling stock)
Scrap processing — cut and shread
Power plant
Machine shop
Boiler shop
Welding shop
Blacksmith shops
Rigger, pipe, carpenter shops
Instrument, electrical (motors) shops
Roll reconditioning shops
Field services
Iron workers
Construction workers
Masons
Track crews

services are supplied from external sources. The cost of production is closely tied in with the degree of plant use. The remote location of any of these services could affect the needed smooth operation of the mill. The costs of these services are likely to be considerably higher than for a mill in a heavy industrial area or a large integrated mill.

Steel Industry Capital Requirements

The steel industry has not had very attractive returns when compared with other investment alternatives. The following ratios are typical:

Net income percent of sales	4.4%
Net income percent of investment	6.5%

For this reason capital requirements are difficult to obtain. Equity capital has been practically non-existent since World War II. Long-term debt borrowing usually averages about 28%. The major source of capital is internally generated. This depends heavily on depreciation and taxation laws. The generation of profits is also very important and is subject to foreign competition and periodic government interference.

Employment costs which average about 35% of sales continue to increase rapidly as do raw material costs. Capital investment costs have also risen dramatically in the last few years and will probably continue to do so. All of this points to the fact that:

1. Equity capital is not a likely source.
2. Internal generation of funds by steel firms does not look encouraging because of rising costs and present legislative restrictions.
3. Debt capital is usually limited to around 28% of the total capital.

VI. ECONOMICS OF MONTANA LOCATION

Iron and Steel Production Facility Location

The following two quotes illustrate the opinion of many authorities in the steel industry:

> "The primary forces influencing the location pattern of iron and steel production within a particular market are the scale economics of manufacturing and the costs of transporting the finished steel products. There is a weakening location attraction of raw material and a trend toward market oriented production."(1)
>
> "It is difficult to draw any very definite conclusions as to any preference in regard to the location of iron and steel plants. The great majority of the plants are situated within easy reach of coal, and indeed very often in the immediate neighborhood of the coalfields. Proximity to iron ore mines does not seem to have a determining factor in plant location . . . It would appear that the biggest factor in these concentrations has been nearness to the major consumer industries."(2)

This fact is highlighted in this section of the report.

Market for Merchant Mill Output

The Mountain and Pacific states regions (see Exhibit 17 for a definition of regions) account for roughly 7% of the steel shipped within the United States. California and Washington account for most of this amount. It is estimated that there is about 750,000-1,000,000 tons of merchant mill sales within these regions per year excluding California. Merchant mill sales account for approximately 15% of total finished steel mill sales. In the

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(1) Source: Manners, Gerald; The Changing World Market for Iron Ore 1950-1980; page 63.

(2) Source: Management, Organization, and Methods in American Iron and Steel Industry; page 58.

EXHIBIT 17

DEFINITION OF REGIONS

Mountain:

Montana
Idaho
Wyoming
Colorado
New Mexico
Arizona
Utah
Nevada

Pacific:

Washington
Oregon
California
Alaska
Hawaii

West South Central:

Arkansas
Louisiana
Oklahoma
Texas

East North Central:

Ohio
Indiana
Illinois
Michigan
Wisconsin

West North Central:

Minnesota
Iowa
Missouri
North Dakota
South Dakota
Nebraska
Kansas

South Atlantic:

Delaware
Maryland
District of Columbia
Virginia
West Virginia
North Carolina
South Carolina
Georgia
Florida

East South Central:

Kentucky
Tennessee
Alabama
Mississippi

New England:

Maine
New Hampshire
Vermont
Massachusetts
Rhode Island
Connecticut

Middle Atlantic:

New York
New Jersey
Pennsylvania

---

absence of price competition, the American steel firms struggle to outbid one another on quality, delivery dates, finishes, and customer service. Delivery dates are commonly 1-3 months.

Merchant bar prices have the following recent history. (Pittsburg, cents per pound):

1969	average	6.575
1970	average	6.991
1971	average	7.813
1972	average	7.229
1973	average	8.375
1974	average	9.74
1974	December	10.75

Prices for merchant bars and reinforcing bars are volatile. They went through the roof in 1974. In the merchant market, served to a large extent by mini-mills, vigorous price cutting has broken out in mid-1975. Now, in mid-1975, price cuts of $60 a ton are reported.

Important factors in the merchant markets are small mills which rely on steel scrap as a raw material. The recent downward direction in scrap prices has lowered costs—just as last year's skyrocketing prices raised them then. Merchant products largely go into construction and have been subject to chronic spells of price weakness. This weakness is now cropping up in outlying markets of the Midwest, the South and Southwest. However, at least one national mill has joined in the price cutting. Buyers suspect the price cutting will spread.

Stainless Steel and Alloy Steel

The market for alloys steel is 10-15% of the size of the carbon steel market. Stainless steel is .5-1% of the size of the carbon steel market.

Stainless steel usually contains about 18% chromium and 8% nickel. Chromium deposits are available in Montana as are nickel deposits. The feasibility of using these deposits needs further investigation.

The production of stainless steel or other ferro-alloys is within the technical capability of an electric furnace. Some additional processing equipment would be required. The western market for these products, however, is small. The finished product would have to be shipped tremendous distances to market. It is therefore doubtful that production of ferro-alloys and/or stainless steel should be pursued. Considerable additional processing and market investigation needs to be done to substantiate this, however.

Comparative Processing Cost of Montana vs. Other Steel Areas

Montana has the cheapest natural gas of any major steel producing state in the North Central and Western States regions. Its price is roughly one-half the average price in these states. This is very encouraging with relation to direct reduction plant development. However, this price structure has been changing rapidly and drastically during the last year and needs a further detailed evaluation. This change is occurring nationwide, but Montana is especially vulnerable because of dependence on the import of Canadian natural gas.

Electrical power in Montana is only 2% cheaper than the average in the surrounding regions. No significant cost advantage would result in this area. The availability and price of power in Montana will be affected considerably by the outcome of the current Colstrip 3 and 4 hearings.

Virtually all steel mills, large and small, are unionized. All mills have an identical contract as far as wages and fringe benefits are concerned.

The 1974 level including fringe was $9.01/hour. The 1975 level would be only slightly higher. Employment costs account for roughly 35% of the cost of sales. Therefore, no cost advantage exists in this area. It is assumed that productivity in a Montana location would be at least equal to other locations.

Scrap Availability and Prices

The Mountain and Pacific States regions consume about 6% of the scrap used in the U.S. This amounts to approximately 8 million tons/year in these regions. Montana and the states adjacent to it produce only a small portion of this total, approximately .3 million tons/year. The proposed mill would therefore require over one-half of the scrap available in the adjacent states.

The recent two-and-a-half-year worldwide boom in steel production may have seriously depleted scrap reserves. If this is the case, steelmen may have to adjust permanently to live with scrap prices well above their historical range of $30 to $50 a ton.

John E. McGee, metals purchasing manager at Armco Steel, the nation's largest ferrous scrap buyer, holds this view. "This country has the lowest inventory of scrap since World War II," says McGee. "We believe that in the next four years there's going to be a serious shortage."

McGee bases his projections on the growing use of electric steelmaking furnaces in the U.S. Such furnaces use 100% scrap charges, compared with about 30% in the basic oxygen furnace. Electric furnaces now make up 23% of U.S. steelmaking capacity, up from 18% ten years ago, and another 5-million tons of electric furnace capacity is slated to come on stream during the remainder of the 1970's.

Less scrap at home may bring more pressure for export controls. Controls were dropped at the beginning of 1975. But there is debate in the industry about their necessity now.

Scrap prices have had the following trend in the last five years. (Price of No. 1 scrap Chicago per gross ton.)

1969	average	30.12
1970	average	41.86
1971	average	33.40
1972	average	36.22
1973	average	57.64
1974	average	112.44
1975	August	54.50

Cost of Raw Materials (F.O.B. source) in Montana

Coal costs have averaged about $2/ton less in the Mountain States region than in other steelmaking states. The cost of iron ore in the Mountain States region is slightly less than in other states. The cost of scrap, limestone, chromite, other ferro-alloys, and other needed materials such as electrodes, should be no higher in Montana than in other locations. Therefore, the total raw materials cost, F.O.B. source, would have a negligible advantage in Montana. The most optimistic finished product cost advantage would be in the range of about 2%. This advantage is negated by the increased transportation cost.

Shipping Distances

It is not uncommon to ship iron ore concentrate or pellets many hundreds of miles by rail and even farther by ship. Other raw materials are usually within a few hundred miles. In the past the shipping costs of the raw materials have been roughly one-half the cost of the material delivered

at the mill. Recent price changes in coal and scrap have caused the material cost to rise faster than the transportation cost. The transportation cost of scrap varies between $5-$25/ton depending on the distance. Scrap shipping rates are usually 2-3 times higher per ton-mile than iron ore.

Exhibit 18 shows the distribution of the shipment of finished steelworks and rolling mill products both from and to the Mountain States. Exhibit 19 gives an indication of the distances of shipments in the U.S.

It can be seen by this summary that about one-half of all shipments are under 200 miles. The closeness of the market is a very important cost consideration. Finished goods transportation cost accounts for roughly 6% of the average delivered cost of the steel.

Steel prices are F.O.B. steel mill. Although there is very little or no price competition in the steel industry, it is common practice to absorb freight costs of distant customers in order to make the product competitive with the prices charged by mills which are geographically closer to that customer.

The ratio of raw material to finished product tonnage is 2:1 for electric furnaces and 2.5:1 for other steelmaking methods. The railroad rates however vary with the value of the commodity being shipped. The finished product cost per ton-mile is typically three to four times as great as for the raw material. The net affect is that distances to market tend to be more critical than distances to raw materials. Raw materials shipments can also often be consolidated into large unit train shipments. Scrap shipping rates are the major exception. They tend to be considerably higher than iron-ore shipping rates.

EXHIBIT 18

STEEL WORKS AND ROLLING MILL PRODUCTS SHIPPING DISTRIBUTION

Geographic Region of Destination or Origin	Percentage shipped from Mountain States	Percentage shipped to Mountain States
Pacific	39.6	11.9
Mountain	32.2	39.2
West South Central	14.7	13.9
East South Central	2.9	7.3
South Atlantic	-	2.5
West North Central	9.4	2.7
East North Central	.1	17.6
Middle Atlantic	1.1	4.8
New England	-	.1
	2,208 million tons/year	1,816 million tons/year

EXHIBIT 19

DISTRIBUTION OF DISTANCES SHIPPED BY LAND OF STEEL WORKS AND ROLLING MILL PRODUCTS IN THE U.S.

Distance Shipped in Miles	Percentage of Tonnage Shipped	Method of Shipment Rail	Truck
Under 200	49	60	40
200 to 399	30	50	50
400 to 599	10	67	33
600 to 999	6	80	20
1,000 and over	5	93	7

Freight Rates on Iron Ore, Coal, and Limestone

Freight rates on these raw materials usually account for about 15% of the cost of the finished product. Limestone/lime is available in Montana and should present no transportation cost problem. Both coal and iron ore are not presently available in Montana. The coal transportation costs would be increased by about $2.50-$5.00 per ton if outside the State sources were required. This would increase the final product cost by about 1.5% to 3%. The same approximate relationship exists for iron ore. Although iron ore shipping rates are somewhat lower than coal, larger amounts must be transported.

Transportation of Finished Product

Because of the remote market location, the shipment of finished product from Montana will have an average distance of 650 miles. The average distance for most mills is around 350 miles. Because shipping costs are not proportional to distance, the cost will not reflect the full mileage differences.

Shipping costs of a Montana steel mill will be about 167% of the average shipping costs of non-Montana mills. This results in a total cost disadvantage of about 4% of the cost of the finished product or about $6/ton.

Scrap Freight

In order to obtain sufficient scrap, an average distance of about 600 miles will be the average shipment. This is probably twice the distance needed for an average non-Montana steel mill scrap shipment. Therefore, the cost increase will be about $7.50 per ton of scrap. This amounts to about $8.50 per ton of finished product or a 6.0% disadvantage.

Tax and Construction Cost Considerations

Three major costs not associated with the processing that have a major impact on the economics of the project are:

1. Relative construction costs within the North Central and Western States.
2. State income tax differences.
3. Property Tax Rates comparison.

Compared with 40 other locations in the U.S., Montana has a relative construction cost no worse than most locations and in some instances, slightly better. Construction costs should, therefore, play no significant role as either an advantage or a disadvantage.

Montana's state income tax is slightly higher than the average for the thirteen major steel producing states in the North Central and Western States. Montana has the fourth highest rate and this rate is 1.5% above the average rate. This accounts for a .25% increase in the cost per ton in comparison with the average state.

Montana property taxes are difficult to compare because of assessment ratios and practices. It appears that Montana has the second highest tax when compared with the steel producing states of the North Central and Western regions of the U.S. The Montana rate is nearly double the average for these states. This would account for a cost disadvantage on the order of 2.25% per ton.

Montana Steel Mill: Summary of Cost Advantages and Disadvantages

A quantitative summary of the relative cost factors is as follows:

Cost Area	Increased Cost as a Percentage of Final Product Cost
Construction Cost	Negligible or slight drop
State Income Tax	+.25%
Property Tax	+2.25%
Shipping Finished Goods	+4.0%
Size of Plant	Negligible or slight increase
Electric Power	Negligible or slight drop

Manpower	Negligible or slight increase
Cost of Raw Material (BOF Furnace)	-2.0%
Transport of Scrap (Electric furnace)	+6.0%
Transport of non-Montana Raw Material (BOF Furnace)	+4.5%
Total (Electric Furnace)	12.5%

It can be seen that a Montana location has a relative cost disadvantage of from 9% to 12.5% when compared to other mills. Because of the isolated market area, however, a Montana mill should be able to competitively service a limited local area. This is due to the fact that other mills would need to ship considerable distance to reach it.

VII. CONCLUSION

Recommendations

A 150,000 ton/year capacity mini-steel mill is the only mill that warrants further consideration at this time. This mill would consist of two small electric furnaces, a continuous casting plant, and a small merchant bar rolling mill. The raw material iron source would be scrap. If a local source of iron could be developed by a direct reduction process, then it would replace the scrap requirement.

This type and size of plant is recommended for the following reasons:

1. Only a small market exists.
2. Alternative processes require a much larger size to be economical.
3. This is the minimum economical size for this type of plant.
4. The investment per ton of output is about one fourth of alternate processes.
5. The return on investment is higher than alternative processes.

6. The technology is simpler than alternative processes.
7. The process has greater production output flexibility.
8. There is much less pollution problem than with alternative processes.
9. This process has the potential of being joined with a direct reduction plant.
10. The raw materials (iron ore and coke) are not currently readily available for the alternative process.
11. This process is adaptable to stainless production.

Potential problems and disadvantages for this plant include:

1. Inadequate scrap supply within a reasonable distance.
2. Suitability of local ore for direct reduction is unknown. Also, direct reduction is dependent upon large quantities of natural gas, the supply and price of which is highly changeable.

The larger plant is economically unfeasible. The resource requirements for this mill are in excess of what a Montana location could provide. The water, power, and manpower requirements are also critical limiting factors. The magnitude of investment is greater on a per ton basis by a factor of 3.5 as well as being about 7 times as large in capacity. The available market is also too small to support the mill output within a reasonable shipping distance.

Location of Facilities

The steel mill location within Montana has three major requirements. In order of importance they are:

1. A work force of approximately 600 people is required. This would suggest that only the largest cities in Montana would be likely locations.
2. The plant requires numerous auxilliary services which would only be available in industrially concentrated areas.
3. Good rail and truck freight connections and facilities are needed. Again the larger cities could provide this.

Ore Beneficiation

If a suitable iron ore deposit can be developed within Montana, then an ore beneficiation facility would almost certainly be developed also. The specifications for this plant would depend on the characteristics of the ore. The facility could range anywhere from simple magnetic separation to a pellet plant to a direct reduction facility.

The product of a pellet plant would be shipped to an area where a blast furnace was being used. If a direct reduction plant were technically feasible, then a portion of the output could be utilized by the mini-steel mill. Such a plant would probably be in excess of 300,000 tons/year capacity so that only one-half of its output would be used by the mini-steel mill.

Location of Ore Beneficiation Facility

The ore beneficiation facility would probably be located within 10 to 20 miles of the mine. The ore would be hauled from the mine by truck. The concentrated ore would be transported to the steel mill by unit trains.

Direct Reduction Feasibility

Sufficient information is not available to evaluate this alternative. Additional analysis and testing of the composition and characteristics of Montana ore deposits must be accomplished first. The availability and price of natural gas or suitable coal must also be studied.

Ownership

Most steel operations are vertically integrated from raw material extraction through final product production. It would be desirable for the mini-steel owner to also own the iron ore mine and direct reduction plant. If the direct reduction plant uses coal, then the coal would also

probably belong to the same company. Many mini-steel mills use scrap as the iron source and therefore are not vertically integrated.

Additional Study Required

This feasibility study was of a preliminary nature. The scope of the study required that approximations be made on most calculations. Nearly all quantity and cost information was obtained from secondary sources. The following list of items were found to be the areas where additional study is required in order to substantiate either the technical or economic feasibility of steel production in Montana. These items are ranked in roughly their order of importance.

1. Iron ore deposits. The published information on the size and composition of Montana deposits is insufficient. Much more detailed and specific information is required in order to establish whether the deposits are suitable for steel use. This information should include the beneficiation processes that would be required to upgrade the ore to useable quality. After this information is available, then additional economic evaluation could be done.
2. Feasibility of direct reduction of iron ore deposits. In conjunction with obtaining more information on Montana iron ore deposits, a study of the possibility of direct reduction of the ore should be conducted. Additional information needs to be gathered on the use of local coal and/or natural gas for this process. Both the price and availability of such a suitable reducing agent and heat source needs to be verified.
3. Transportation cost analysis. A much more thorough study of the transportation costs must be accomplished. The specific rate structure for the various raw materials and finished product needs to be analyzed. This was not possible in this study since the raw material locations were not firmly established. Also, the finished product shipping was only approximate since specific enough market information wasn't determined.
4. Availability and price of power, energy, transportation, manpower, water, and auxilliary services. Additional contact needs to be made with utility and rail companies

to more fully determine the availability and cost of their required services. Also the availability or development of appropriate manpower needs must be further studied.

5. Scrap availability and price analysis. If direct reduction does not prove feasible, then additional study must be done on scrap since it would be the major raw material.
6. Market analysis. A more thorough investigation of the size and characteristics of the market must be accomplished. The prices and quantities must be established more accurately.
7. Investigation of Montana taxes and mining laws. Further study is needed in this area.
8. Investigation of the technology, market, and economics of stainless steel production. The possibility of manufacturing stainless steel as well as other alloy steels needs to be investigated further.

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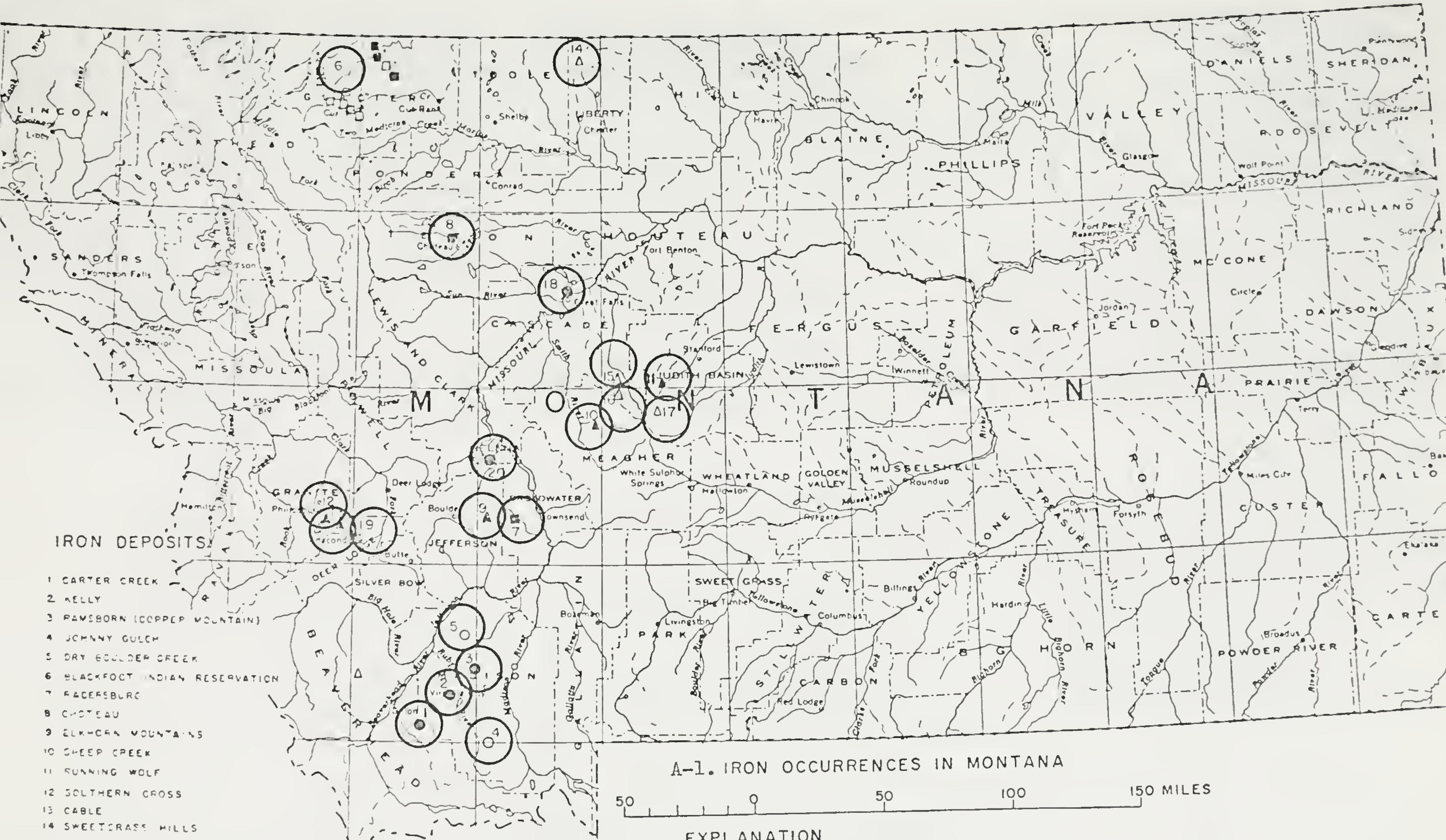
APPENDIX A

MAPS OF MONTANA RESOURCES AND SERVICES

1. Map of Iron Occurrences
2. Map of Coal Occurrences
3. Map of Limestone and Dolomite Occurrences
4. Map of Discharge of Principal Streams
5. Table of Discharge of Principal Streams
6. Map of Water Well Potential
7. Montana Roads
8. Rail Map of Montana
9. Electric and Gas Map of Montana



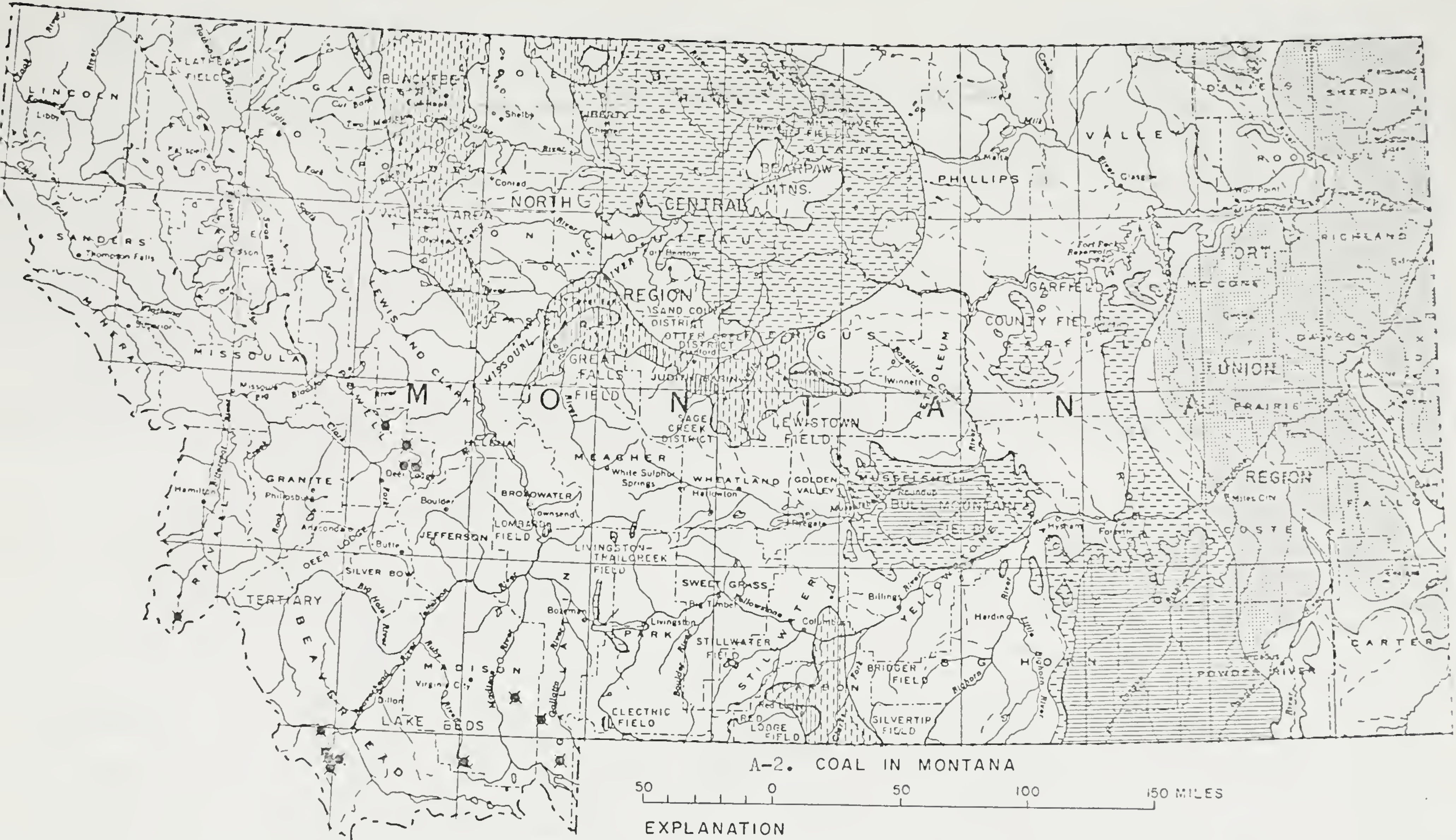
A-1. IRON OCCURRENCES IN MONTANA

IRON DEPOSITS

1 CARTER CREEK
2 KELLY
3 RAMSBORN (COPPER MOUNTAIN)
4 JOHNNY GULCH
5 DRY BOULDER CREEK
6 BLACKFOOT INDIAN RESERVATION
7 RADERSBURG
8 CHOTEAU
9 ELKHORN MOUNTAINS
10 SHEEP CREEK
11 RUNNING WOLF
12 SOUTHERN CROSS
13 CABLE
14 SWEETGRASS HILLS
15 THUNDER MOUNTAIN
16 IRON MOUNTAIN
17 YOGO PEAK
18 GREAT FALLS SLAG
19 ANACONDA SLAG
20 HELENA SLAG

EXPLANATION

TYPE OF DEPOSIT	DEPOSITS THAT MAY HAVE SIGNIFICANT POTENTIAL	POTENTIAL UNEVALUATED
SEDIMENTARY PRECAMBRIAN	●	○
BEACH SAND TITANIFEROUS MAGNETITE	■	□
MAGMATIC AFFILIATION	▲	△
SMELTER SLAGS		▨



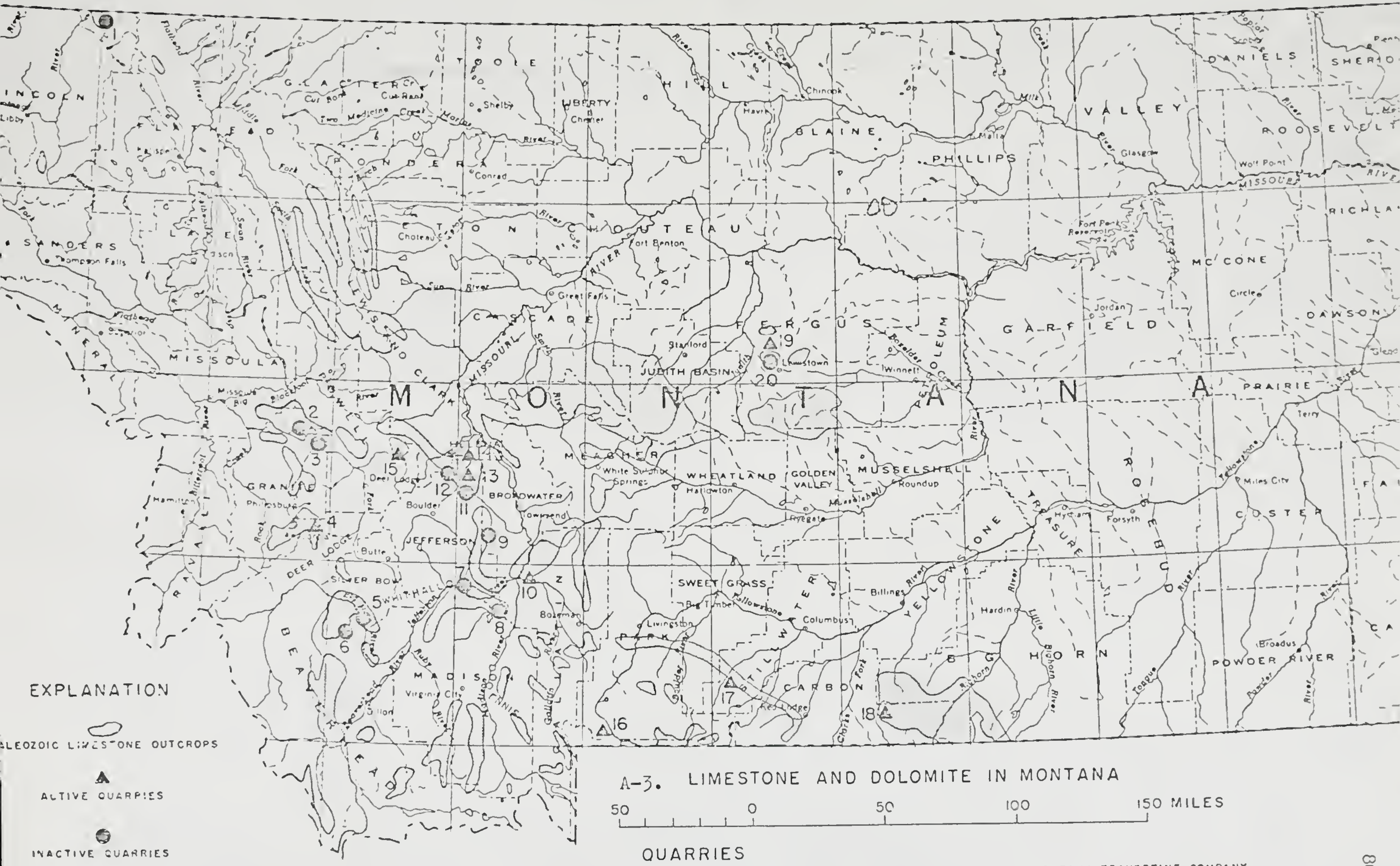
A-2. COAL IN MONTANA

EXPLANATION

	BITUMINOUS COAL	SUB-BITUMINOUS COAL	LIGNITE
AREAS OF THICK CONTINUOUS COAL BEDS	▥ MORE THAN 14 INCHES THICK	▤ MORE THAN 30 INCHES THICK	▩ MORE THAN 30 INCHES THICK
AREAS OF THIN, OR DISCONTINUOUS COAL BEDS	▥ LESS THAN 14 INCHES THICK	▤ LESS THAN 30 INCHES THICK	☐ LESS THAN 30 INCHES THICK

☒ KNOWN OCCURRENCE OF LIGNITE IN TERTIARY LAKE BEDS

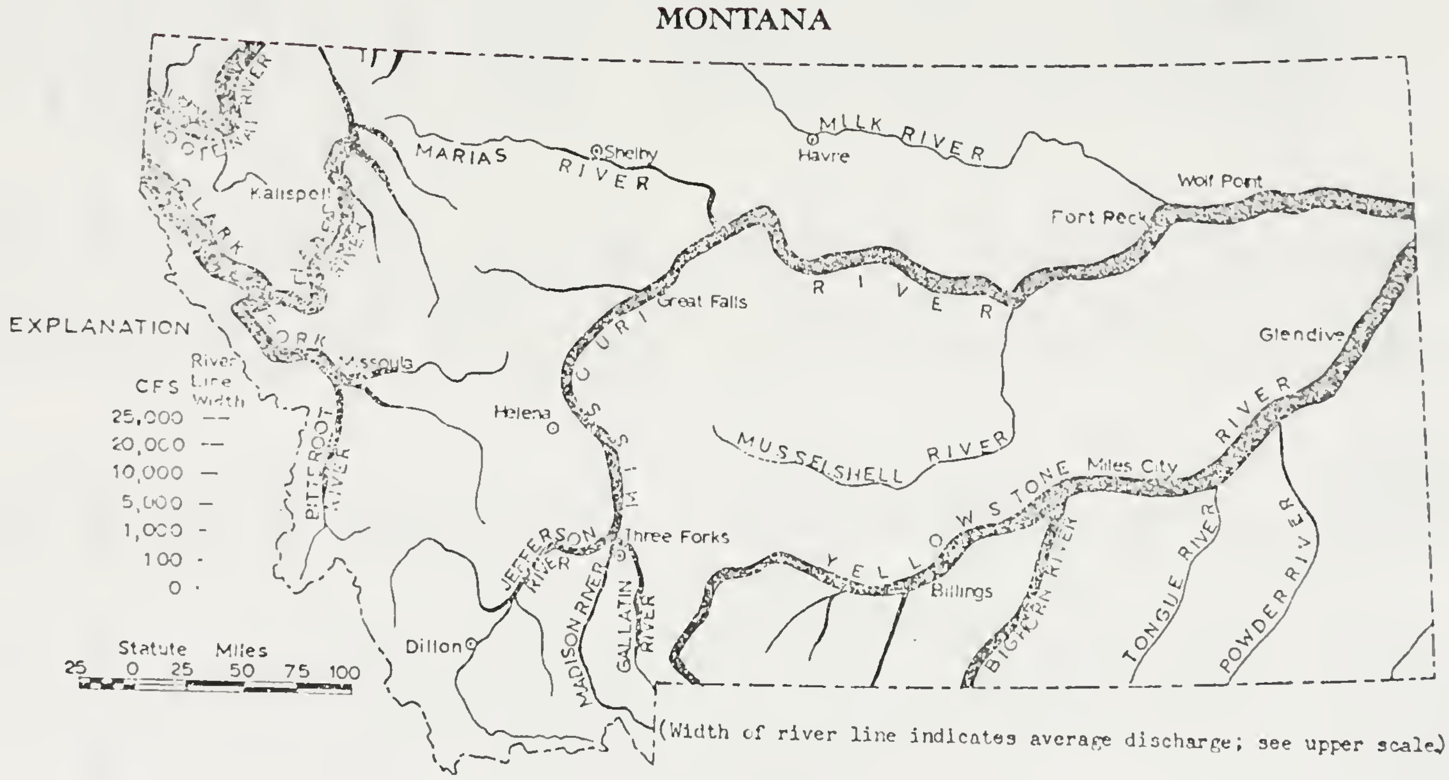
AFTER COMBO AND OTHERS 1949



A-3. LIMESTONE AND DOLOMITE IN MONTANA

QUARRIES

1. STAHL
2. HITCHCOCK
3. DRUMMOND
4. BROWNS
5. ANTONIOLI
6. MAIDEN ROCK
7. LIMESPUR
8. SAPPINGTON
9. VERMONT MARBLE
10. IDEAL CEMENT COMPANY
11. MONTANA CITY
12. HARRIS
13. PERMANENTE CEMENT COMPANY
14. MARONICK
15. ELLISTON LIME COMPANY
16. MONTANA TRAVERTINE COMPANY
17. AMERICAN CHROME COMPANY
18. WARREN
19. PARADISE TRAVERTINE
20. HANOVER



(Width of river line indicates average discharge; see upper scale)

A-4. Map of Discharge of Principal Streams

A-5. Table of Discharge of Principal Montana Streams

Stream	Drainage Area (square miles)	Years of Record	Average Discharge (cubic feet per second)	Extremes Of Discharge (cubic feet per second)		Irrigated Land Served (acres)
				Max.	Min.	
Red Rock River below Lima Reservoir near Modina	570.0	40	138	2,500	0[1]	10,000
Beaverhead River at Blaine	3,619.0	26	390	3,130	7.0	115,000
Ruby River near Twin Bridges	935.0	16	188	1,500	1.8[2]	28,000
Big Hole River near Melrose	2,476.0	38	1,091	14,100	49.0	136,000
Boulder River near Boulder	381.0	30	110	2,620	0	3,500
Jefferson River at Sappington	9,277.0	32	2,093	21,000	134.0	345,000
Madison River near West Yellowstone	420.0	46	471	2,150	100.0	0
Madison River below Ennis Lake near McAllister	2,186.0	23	1,594	7,750	210.0[2]	23,000
Gallatin River near Gallatin Gateway	825.0	36	755	8,060	117.0	1,400
Bridger Creek near Bozeman	62.5	16	32	902	.9	1,200
Gallatin River at Logan	1,795.0	45	949	9,840	130.0	110,000
Missouri River at Toston	14,669	26	5,135.0	32,000	562.0	535,000
Prickly Pear Creek near Clancy	192	35	47.7	927	.5	700
Missouri River below Holter Dam near Wolf Creek	17,149	16	5,023.0	34,900	500.0	574,000
Dearborn River near Craig	325	16	216.0	7,960	8.0	3,300

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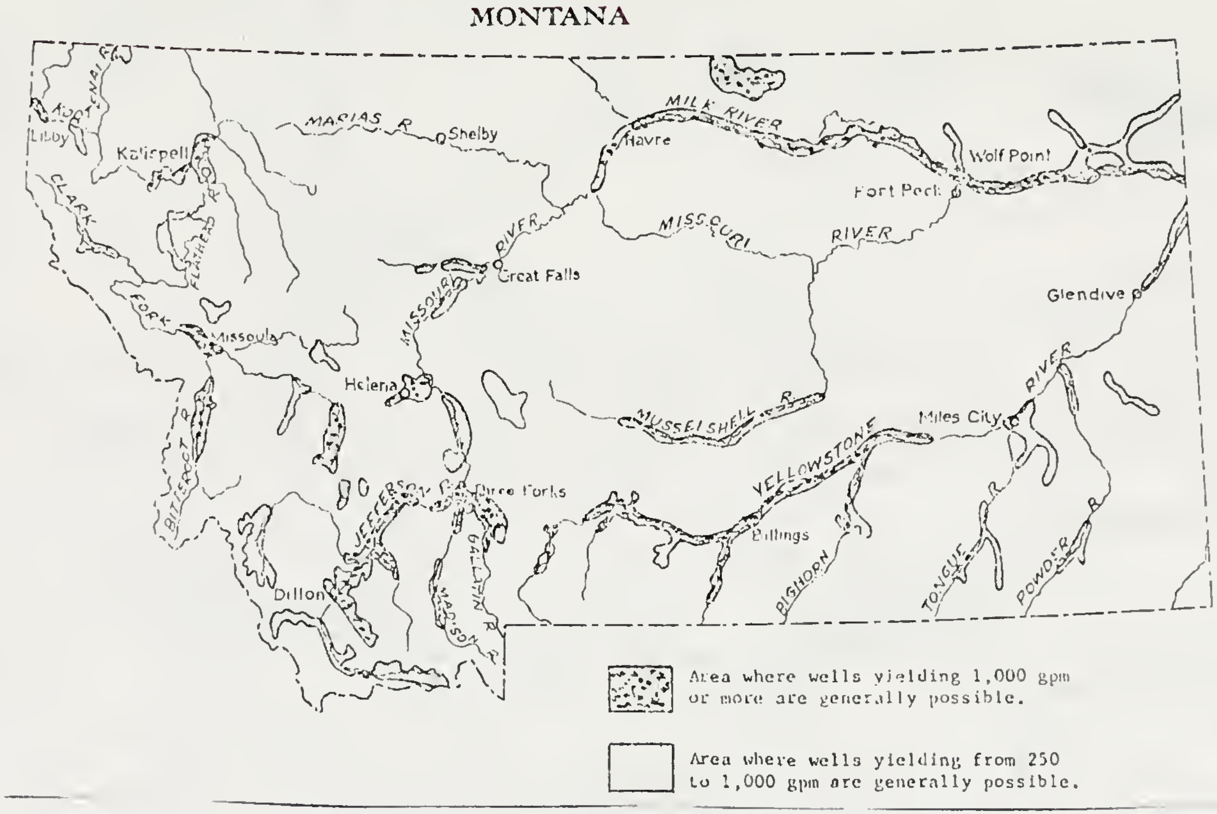
[1] Regulated

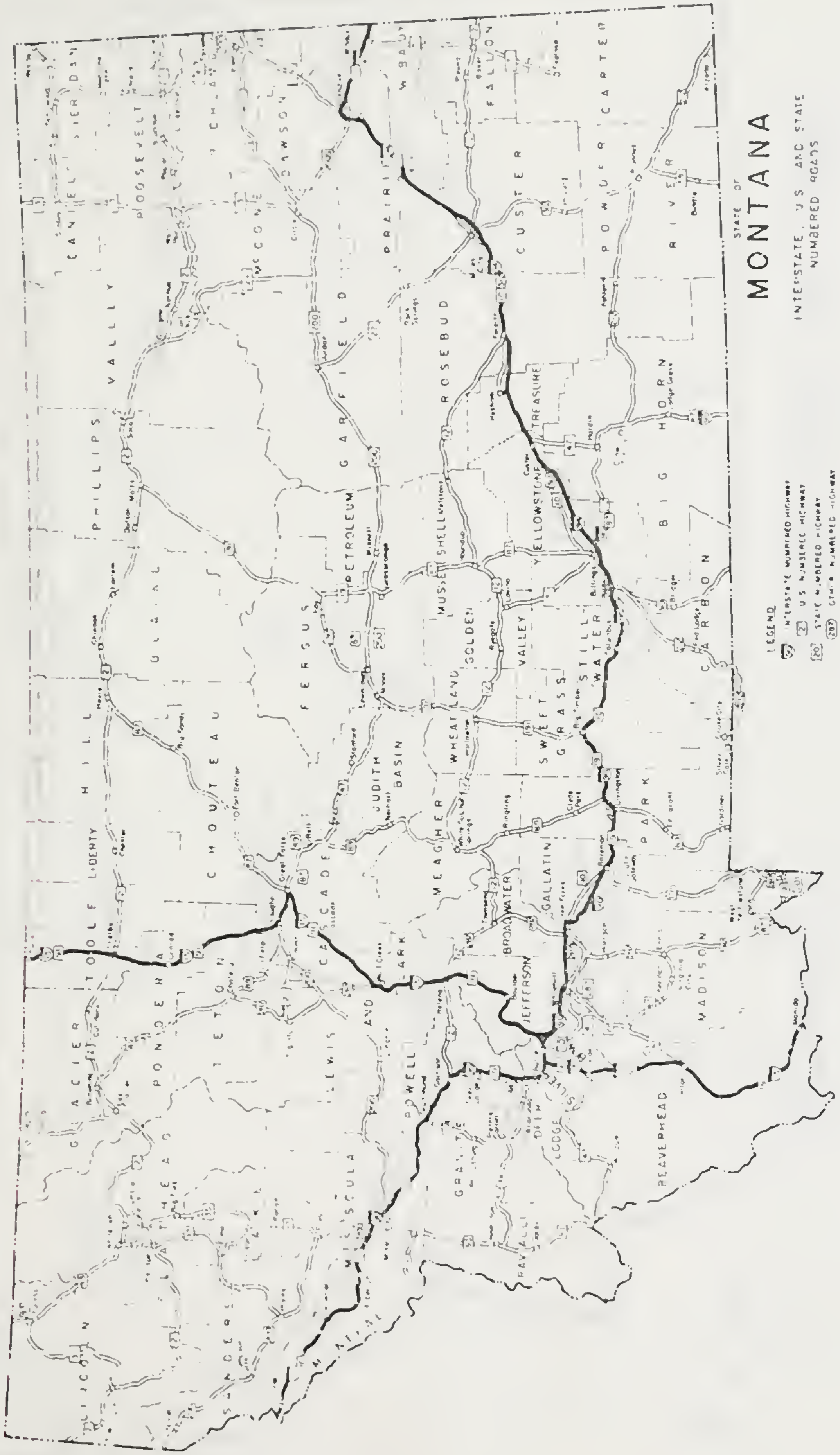
[2] Minimum daily

A-5. Table of Discharge of Principal Montana Streams (cont.)

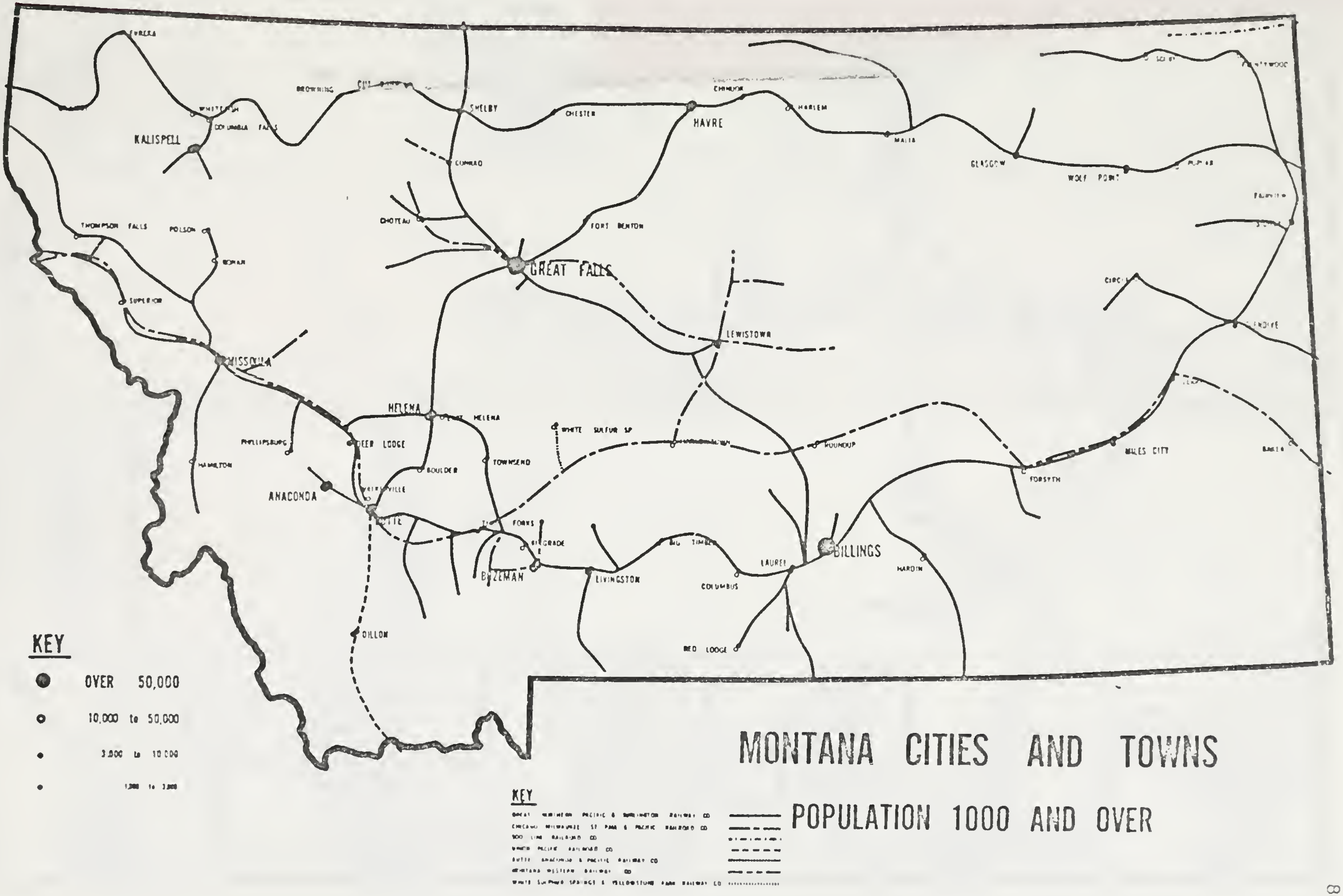
Stream	Drainage Area (square miles)	Years Of Record	Average Discharge (cubic feet per second)	Extremes Of Discharge (cubic feet per second)		Irrigated Land Served (acres)
				Max.	Min.	
Smith River near Eden	1,594	10	252.0	12,300	3.1	24,500
North Fork Sun River near Augusta . . .	258	17	360.0	4,840	27.0	0
Sun River near Vaughn	1,854	27	713.0	17,900	20.0	110,000



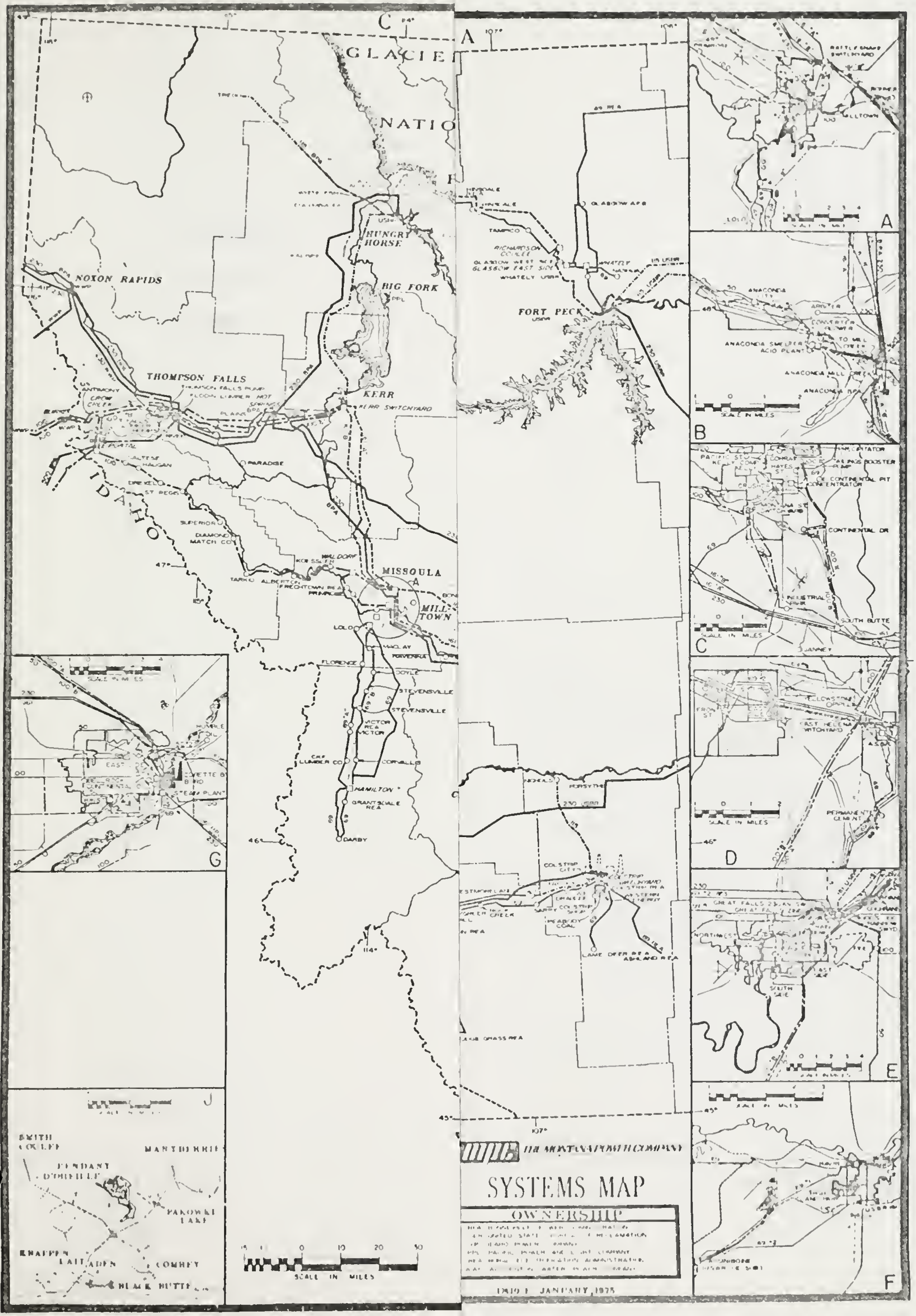
A-6. Map of Water Well Potential



A-7. Montana Roads



A-8. Rail Map of Montana


THE MONTANA POWER COMPANY
SYSTEMS MAP
OWNERSHIP
DATED JANUARY 1975
GLACIER NATIONAL PARK
IDAHO
HUNGRY HORSE
BIG FORK
NOXON RAPIDS
THOMPSON FALLS
KERR
KERR SWITCHYARD
PARADISE
ST. REGIS
SUPERIOR
DIAMOND MATCH CO.
MISSOULA
MILLTOWN
LOLO
FLORENCE
STEVENSVILLE
VICTOR
CORVALLIS
HAMILTON
DARBY
FORT PECK
GLASGOW AFB
GLASGOW WEST SIDE
GLASGOW EAST SIDE
WHATELY
TAMPICO
FORSYTHE
COLSTRIP
LAME DEER REA
ASHLAND REA
SCALE IN MILES
ANACONDA SMELTER ACID PLANT
ANACONDA MILL CREEK
CONTINENTAL DR
SOUTH BUTTE
EAST HELENA SWITCHYARD
PERMANENTE CEMENT
GREAT FALLS
SOUTH SIDE
SMITH COULEE
PENDANT D'OREILLE
MANYBERRIES
PAKOWKI LAKE
KNAPPEN
COMREY
BLACK BUTTE
A
B
C
D
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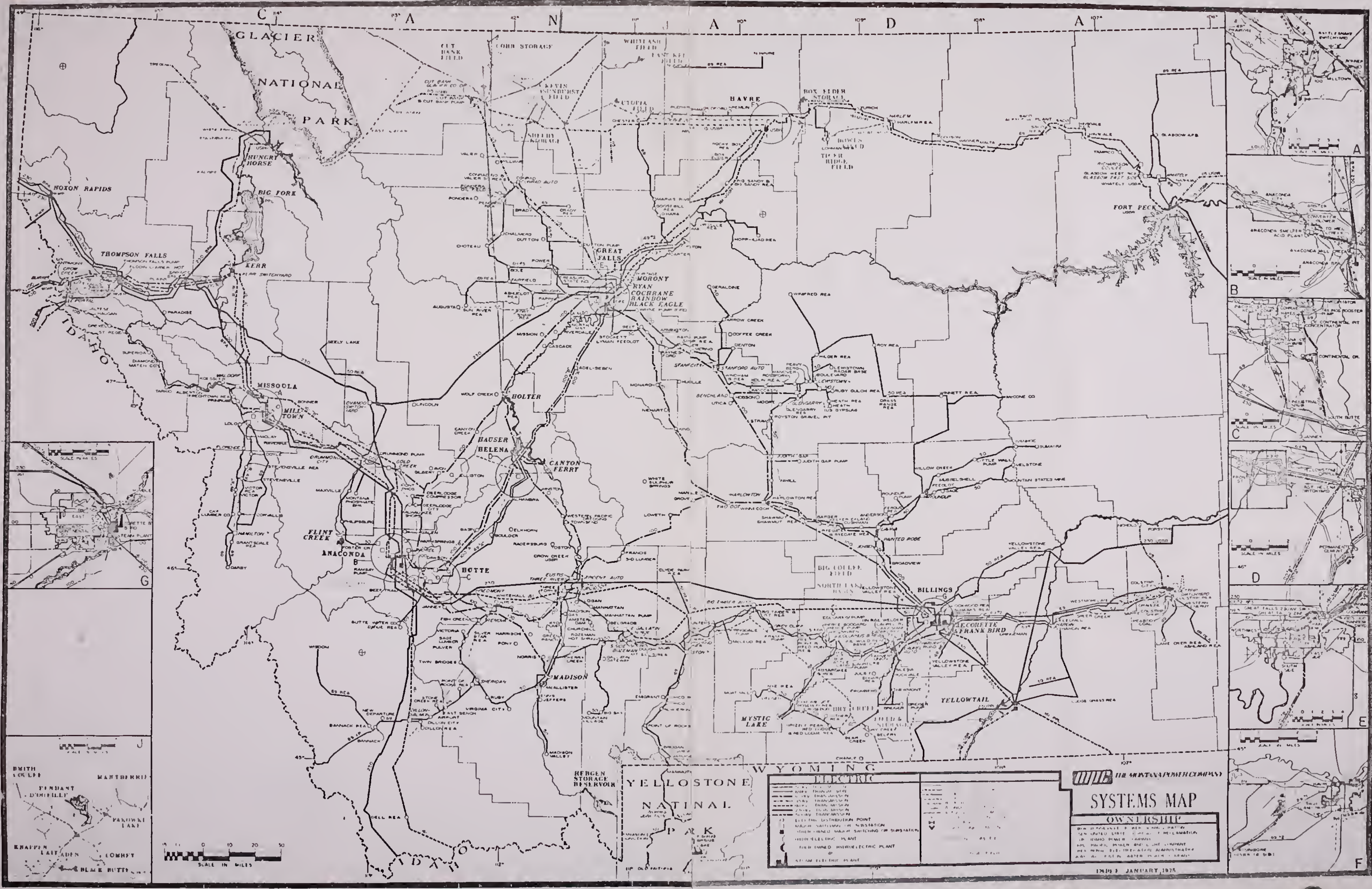
G
J
45°
46°
47°
107°
114°


CANADA
GLACIER NATIONAL PARK
IDAHO
WYOMING
YELLOWSTONE NATIONAL PARK
NOXON RAPIDS
THOMPSON FALLS
KERR
HUNGRY HORSE
BIG FORK
MISSOULA
MILLTOWN
HAVRE
GREAT FALLS
MORONY
RYAN
COCHRANE
RAINBOW
BLACK EAGLE
HOLTER
HAUSER
HELENA
CANYON FERRY
FLINT CREEK
ANACONDA
BUTTE
MADISON
HEBGEN STORAGE RESERVOIR
MYSTIC LAKE
BILLINGS
CORETTE
FRANK BIRD
YELLOWTAIL
FORT PECK
CUT BANK FIELD
KEVIN SUNBURST FIELD
BOX ELDER STORAGE
BOWES FIELD
TIGER RIDGE FIELD
BIG COULEE FIELD
NORTH LAKE BASIN
DRY CREEK FIELD & STORAGE
ELECTRIC
Electric distribution point
Major switching or substation
Other owned major switching or substation
Hydroelectric plant
Other owned hydroelectric plant
Steam electric plant
THE MONTANA POWER COMPANY
SYSTEMS MAP
OWNERSHIP
USBR United States Bureau of Reclamation
IP Idaho Power Company
PPL Pacific Power and Light Company
REA Rural Electrification Administration
SCALE IN MILES
DATED JANUARY 1975
A
B
C
D
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APPENDIX B

RAW MATERIAL SPECIFICATIONS

1. Limestone
2. Iron Ore
3. Scrap

APPENDIX B

RAW MATERIAL SPECIFICATIONS

1. Limestone
2. Iron Ore
3. Scrap

1. Specifications For Limestone Used in Steel Making[1]

General specifications for various uses of crushed limestone are listed below (percent):

Flux, etc.:

Bessemer — Upper limits: S, 0.5%; P_2O_5, 0:01%.

Blast furnace charge — Upper limit: $MgCO_3$, 20 to 30%; Al_2O_3+Fe_2O_3, 4%; SiO_2, 3 to 4%.

Patching and lining — Lower limits: $MgCO_3$, 35%.

Open hearth — Upper limits: $MgCO_3$, 20%; SiO_2, 1%; S, 1%; P_2O_5, 1%.

Application: Flux for refining ferrous and nonferrous metals.

Specific use or process: Blast furnaceflux: Limestone, calcitic and dolomitic, or blends of limestone and dolomite used in smelting metalliferous ores by combining with gangue (impurities) to form an immiscible slag. The fluxing material must be as pure as possible within economic limits, since the objective of the flux is to remove impurities as efficiently as possible.

Specifications: Chemical: Varying, depending on cost and availability considerations, but generally the following constituent limitations apply: SiO_2-maxima of 1 to 5 percent; S-maxima of 0.1 to 0.5 percent; P-maximum of 0.05; MgO-maxima of 4 to 15 percent. However, about half of the steel mills in the U.S. will permit no more than a total of 3 percent noncarbonate impurities, including approximate maxima of 0.1 percent sulfur and 0.02 percent phosphorus. Physical: Size ranges: 1 x 4 inches, 2 x 4 inches, 2 x 2½ inches, and 6 x 3 inches -fine fragments undesirable. Quality: a strong, finegrained stone that will not decrepitate under furnace heat is required.

Specific use or process: Open hearth flux: Limestone, usually the high calcium type, is used rather than magnesian stone because the removal of phosphorus occurs in the open hearth and CaO has a greater affinity for phosphorus than does MgO.

Specifications: Chemical: For high calcium limestone generally 98 percent $CaCO_3$. For other limestone: Al_2O_3- less than 1.5 percent; SiO_2 - 2 percent maximum; $MgCO_3$-10 percent maximum; P-trace amounts only; S-undesirable - only trace amounts tolerated. Physical: Size range: Generally similar to blast furnace use.

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[1] Source: Mineral and Water Resources of Idaho, p. 112.

2. Iron Ores[1]

A. Classification

Iron ore occurs in several chemical combinations and in various mineralogical forms. Deposits are widespread, though not always readily available to sources of consumption, or of sufficient quantity and quality to be mined profitably. The rapid growth of industry in recent years has stimulated the search for new raw-material sources and numerous research projects to develop more complete utilization of accessible deposits. During the interim between the two World Wars, it appeared that the discovery of new deposits would provide sources far in advance of needs. This, however, has not proved to be the case. The magnitude of iron-ore requirements of the Second World War and the period after it have modified that impression, and lower-grade ores are being developed to an increasingly greater extent.

The character, texture, and composition of the ores from each district reflect their geological heredity and local environment. Although the chemical composition of ores is most important, physical structure and texture of the ore affect the economics of mining and its adaptability as a furnace feed.

Dense massive ores which break into lumps when mined are called hard ores, and those resulting in granular and earthy products are called soft ores. At the extremes of texture gradation, lump ores of suitable chemical analysis are used for open hearth charge and feed ore and command a premium, while fine, earthy ores are subjected to a price penalty. Iron ores also have been classified locally according to their origin or color, and such terms have gained general usage as brown ores, red ores, magnetic ores, and bog ores.

Iron ores are classified further as to Bessemer (phosphorus .045 percent or less), non-Bessemer (phosphorus .045 percent to .180 percent), high phosphorus (phosphorus greater than .180 percent), high sulfur, manganiferous, siliceous, carbonate, and titaniferous, according to their chemical composition. Manganiferous iron ores contain 5 to 10 percent of manganese in addition to iron, and ores having manganese exceeding 3 percent claim a slight premium. Siliceous ores (over 18 percent silica) are used to make silvery pig iron.

B. Mineralogy

Iron Minerals

In most iron-ore deposits hematite, magnetite, siderite, or limonite predominates, and other iron minerals, such as martite, goethite, turgite, fayalite, xanthosiderite, pyrite, pyrrhotite, or marcasite, are associated in smaller quantities. Some of these may be present in very small percentages, and others may constitute a substantial part of the ore. Magnetite ores exposed to weathering conditions may be partly altered to hematite, with resulting mixtures of the two most important iron minerals.

Hematite: Ferric oxide of iron (Fe_2O_3); iron content, 69.9 percent. Most abundant ore mineral. Color: Metallic gray to bluish black in hard

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[1] Source: Iron Ore Material Survey, U.S. Dept. of Interior, May 1956.

crystalline forms. Red to reddish brown in soft ores, which are partly altered to other minerals. Hardness: 5.5-6.5 in solid lumps, ranges 1-5 in less compact ores. Specific gravity: 4.9-5.3 for hard, crystalline ore, ranges down to 3.8 for unconsolidated ores. Occurrence: Mainly as bedded deposits in sedimentary rocks. Usually associated with other iron minerals. Sometimes is an alteration product of other minerals.

Magnetite: Ferrosoferric oxide of iron (Fe_3O_4 or FeO, or Fe_2O_3); iron content, 72.4 percent. Important ore mineral; responds to magnetic concentration. Color: Iron-black. Hardness: 5.5-6.5. Specific gravity: 5.17-5.18. Property: Magnetic. Occurrence: Often as veins and stringers in igneous rocks; frequently disseminated in rock to form a larger ore body or low grade, often as replacement in sedimentary or metamorphosed rocks; as black sand in beach deposits; and as banded layers in metamorphosed and igneous rocks.

Brown Ore: Hydrous ferrosoferric oxides of iron ($FeO.\ Fe_2O_3.\ XH_2O$); iron content 57 to 66 percent; complex mineralogy; important ore consisting of a group of minerals in various degrees of hydration as well as crystal structure; usually carries substantial quantity of free moisture; includes limonite, turgite, goethite, lepidocrite, hydrogoethite, xanthosiderite, limnite, and esmaraldaite.

Siderite: Ferrous carbonate of iron ($FeCO_3$); iron content 48.3 percent; constituent of other iron ores but not important in the United States. Color: Gray to brown, yellow and red stains resulting from oxidation and and hydration. Hardness: 3.5-4. Specific gravity: 3.8-3.9. Occurrence: Widely distributed in small quantities in shale, carbonate sediments, and altered igneous rocks. Minable deposits are rare. Michipicoten sinter is made from manganiferous siderite in Ontario.

Fayalite: Silicate of iron ($FeSiO_4$); iron content, 51.9 percent; associated with other iron minerals; is not considered an ore mineral because it is not reduced in ordinary smelting operations.

Martite: Sesquioxide of iron (Fe_2O_3); properties similar to hematite. Occurs with magnetite, probably alteration product pseudomorphic after magnetite or pyrite.

Pyrite: Sulfide of iron (FeS_2); iron content 46.6 percent; contaminant of iron ores; source of byproduct ore as residue after burning in the manufacture of sulfuric acid. Color: Pale metallic yellow. Hardness: 6-6.5. Specific gravity: 4.95-5.1. Occurrence: Common mineral of wide distribution.

Marcasite: White iron pyrite (FeS_2); differs from pyrite in color, structural appearance, and crystal form.

Other Minerals

Impurities frequently make a material unusable despite high iron content. An outline of the nature and basic effect of several major impurities normally encountered in iron ore may be helpful.

Silica acts as an acid in a blast furnace and must be fluxed with a base, such as lime or magnesia, to form a suitable slag that can be separated from the molten iron in the furnace. For each pound of silica entering

the furnace, about 2 pounds of limestone is required for fluxing purposes. Although some slag is necessary for proper operation of a blast furnace, excessive quantities of silica not only lower the grade of the iron ore itself, but the necessary addition of limestone further reduces the effective grade of the furnace feed. An important additional factor in this connection is that the coke requirement is increased when low-grade ores are used.

Alumina (Al_2O_3) generally acts as an acid in the blast furnace and thus can appreciably affect furnace operation costs and production. However, some alumina in the slag improves operation of the furnace.

Lime (CaO) usually is considered a desirable impurity in iron ores, provided it does not exceed the silica plus alumina content of the ore. Some value in furnace operation is probably gained when lime is intimately admixed with iron minerals, as in the Birmingham, Alabama, district.

Magnesia (MgO) in the blast furnace acts in the same manner as lime, except that high-MgO slags have favorable low melting points.

Sulfur is a highly objectionable impurity in iron ore because it is rejected in the blast furnace only with difficulty and at appreciably added expense. Furnace operators usually will not accept ores containing over 0.1 percent of sulfur.

Phosphorus, depending on the ultimate use of iron from the ore, may be either desirable or objectionable. When the pig iron is to be used to make steel, phosphorus in the ore preferably should be less than 0.1 percent. Conversely, pig iron produced from ores containing up to 2 percent or more of phosphorus is utilized in limited quantities in manufacturing complicated castings where high fluidity is needed and great strength unnecessary.

Manganese is desirable in most iron ore, as it imparts added strength to the iron and facilitates steelmaking operations by assisting in sulfur control.

Titanium has an acid reaction in the blast furnace and must be fluxed as with other acid materials. An additional objection is the fact that titanium sometimes forms accretions in the furnace that are not melted at ordinary furnace temperatures. These tend to foul the furnace. Unless the titanium content of the ore is high enough to warrant byproduct recovery of titanium from the slag, titanium-bearing iron ores containing more than a few tenths percent of titanium are objectionable.

C. Uses, Consumption, and Stocks

Furnaces making iron and steel products consume over 99 percent of all iron ore produced. Miscellaneous uses include cement, pigments, ship ballast, pharmaceuticals, fertilizer, stock feed (enrichment), heavy-medium, nonferrous flux, and electronic applications.

Blast-furnace operators, as the largest users of iron ore, have general specifications modified by individual requirements, traditional practice, and availability of ore. The last factor is perhaps most influential, inasmuch as iron can be smelted from very low grade materials. However, operators strive for efficient practice in order that the iron produced can be sold at competitive prices. Coke is the most expensive material

consumed, and it follows that the use of high-iron-content ores require less coke than ores with a greater percentage of gangue that must be slagged.

The average iron content of blast-furnace ores consumed in the United States is 50 to 51 percent. Furnaces using ore from the Lake Superior district exclusively are still able to depend on consistent analyses that permit operation based on long-established practice. Furnaces using ore from Utah, Wyoming, and Eagle Mountain, Calif.,are adjusted to slightly richer ores, and furnaces in Alabama have been accustomed to much lower grade ores, the use of which has been possible primarily because of savings in transportation costs. The lower limit of iron content in an ore for blast-furnace use is almost entirely a matter of economics. However, the reverse is not true. Very high-iron-content ores are usually diluted by blending with other ores, not only to enrich the poorer materials but because blast-furnace charges must contain enough gangue to form a suitable slag. The best materials contain impurities that it is the slag's function to absorb. Moreover, slag character, checked by sampling runoffs between tapping periods and controlled by added fluxes plus furnace temperature variations, is the most important guide to the quality of metal being produced. Blast-furnace ores rarely average above 55 percent iron content for any particular furnace, although ores up to 70 percent may be blended to make the average charge.

Physical character of blast-furnace ore is important, inasmuch as the reducing gases react best when the greatest ore-surface area is available for contact. Large, non-porous lump ores react slowly, and fine earthy ores tend to clog the furnace as well as drift out of the furnace with the top gases. Ideal ore would be of uniform size and perhaps $\frac{1}{4}$ inch in greatest diameter. Actually the furnace operator must use the sizes available with such treatment (crushing, screening, sintering, blending) as can be performed economically to improve the efficiency of the smelting operation. At present, the available ores carry too large a proportion of fines, and most furnaces employ collectors of one type or another to recover that part blown out of the furnace. In 1952 recovered flue dust in the United States totaled about 9 million net tons.

Of the gangue constituents in the ore, silica, alumina, lime, and magnesia are important in slagmaking. In the United States an excess of the first 2 in the ore necessitates adding the last 2 to provide a suitable chemical balance. Naturally balanced ores are self-fluxing, and in England, silica and alumina must be added as flux. Other elements or mineral constituents (except water) are usually considered according to whether they enter metal or slag. Furnace temperature and slag character influence the disposition of these materials between metal and slag to a degree, but except for manganese and in specific instances phosphorus all are undesirable in blast-furnace ores. Water, or course, increases coke consumption as well as transportation costs. Siderite, (iron carbonate), as a blast-furnace ore, requires extra coke to drive off combined carbon dioxide, and if used in too large proportions, the powdery residue would complicate furnace operation in a number of ways.

By blending various ores blast furnaces can use a variety of analyses, one ore diluting the undesirable constituents of another. However, it follows that the usability of a particular ore may be contingent upon the availability of other ores suitable for blending. An ore usable without blending could fall within the following specifications for blast-furnace use:

Size:	All passing	2-inch screen
	70 percent passing	1-inch screen
	Not more than 20% passing . . .	1/8 inch screen
Analysis:	Fe	50-55% (natural)
	Mn	0.8-1.5
	SiO_2 plus Al_2O_3	10 max.
	CaO plus MgO	(usually low)
	P	0.18 max.
	S	0.10 max.
	Cu, Pb, Zn, As, V, Cr, Ni . . .	0.05 (combined)
	TiO_2	1.0 max.
	H_2O	10 max.

Basic open-hearth steel furnaces use pig iron and scrap as the primary sources of metal and iron ore as a vehicle for oxygen, which transfers to such impurities as carbon, silicon, manganese, sulfur, and phosphorus. Oxidation of excess carbon generates carbon dioxide and causes the bath to boil turbulently. During this turbulence and subsequent phases of the refining process, the impurities are reduced to the desired level by passing off as gas or as liquids absorbed in the slag.

The ore used for this purpose must be hard lumps dense enough to sink through the slag. Density is increased by high iron content, but also, high-grade materials introduce less new impurities while providing the most available oxygen per unit of volume. High silica in basic open-hearth ores is particularly undesirable because additional limestone must be provided to prevent the slag from corroding the furnace lining. Distinct economies and improved operation have been proved by the use of such near-perfect iron ores as those from Liberia and Brazil. Swedish lump magnetite and domestic lump magnetite also are desirable for open-hearth use. Steep Rock and Lake Superior lump hematite is in good demand, but other domestic ores are used only because those named are not available without excessive transportation costs.

Relatively small quantities of iron ore are used in low-temperature methods of reduction for mading sponge iron which is processed to iron powders. The ore is reduced by several methods, including exothermic reaction with aluminum powder, gaseous reduction, electrolysis, and in tunnel kilns where ore and coke breeze are mixed with small quantities of flux in saggers. Ore for this use must be finely divided and, because there is no liquid slag to absorb impurities, of excellent quality. Twice-processed magnetite concentrates and Brazilian fines are especially suitable for this use. Sponge iron of less exacting quality than is required for iron powders is made by the Anaconda Copper Co. in Montana for use in precipitating copper from acid solutions. This use has some possibilities for modest expansion where scrap iron and steel (usually tin cans) are too expensive or not available in sufficient quantity.

Iron ore carrying 40 to 48 percent iron with 20 to 30 percent silica and virtually no other constituents except water and oxygen is used to make silvery pig iron, a low-silicon alloying metal. Combinations of iron ore and quartzite are smelted together in electric furnaces to make ferro-silicon of varying ratios of iron to silicon. Occasionally, ferromanganese manufacturers use iron ore to adjust the product to standard specifications, and a long-standing use for ore of varying quality is in nonferrous smelters as a basic flux.

3. Scrap For Steelmaking[1]

Scrap consists of the by-products of steel fabrication, and worn out, broken or discarded items containing iron or steel. Scrap in the form of iron or steel is one of the two principal sources of metallics in steelmaking; the other principal source is iron from the blast furnaces, either molten as it comes from the blast furnace ("hot metal") or in solid pig form. Scrap is of great practical value. Every ton of scrap consumed in steelmaking is estimated to displace and conserve for future use 3½ to 4 tons of other natural resources including iron ore, coal and limestone. On the average, the steel industry consumes about one-fifth more pig iron than scrap. According to recently published figures of the American Iron and Steel Institute, the steel industry consumes an average of about 55 million tons of iron and steel scrap in producing 100 million net tons of raw steel.

The various steelmaking processes differ widely in their abilities to consume scrap. The air-blown acid Bessemer process (no longer used in the United States) used about 6 percent; the basic oxygen steelmaking process uses 25 to 30 percent; and the Kaldo process about 40 percent. The duplex open-hearth process (not any longer used in this country) consumed very little scrap; while the stationary open-hearth processes may utilize 35 to 60 percent. The electric furnace usually is charged almost entirely with cold scrap.

Types and Sources of Scrap—Scrap iron and steel may be classified as originating from two sources: home scrap produced as unsalable products unavoidably resulting from steelmaking and finishing operations, and purchased scrap.

Home scrap (also called "revert scrap") includes such items as pit scrap; ingots too short to roll; rejected ingots; ingot crops; crop ends from blooms and billets; shear cuttings from trimming flat-rolled products to specified size; products irrecoverably damaged in handling or finishing; ends cut from structural shapes, rails, bars, pipe or tubing to bring them to standard or exact ordered length; turnings from machining operations, broken molds, obsolete machinery, dismantled buildings, steel shot recovered from slag, and so on. Bloom crops constitute the largest single item of home scrap.

In general, about 35 million net tons of home scrap would result from the manufacture of 100 million net tons of raw steel and the processing of this steel into finished mill products.

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[1] Source: The Making, Shaping, and Treating of Steel.

Purchased scrap is used to the extent of 20 million net tons to supplement the 35 million net tons of home scrap to provide the 55 million net tons of iron and steel scrap used to produce the 100 million net tons of steel. Purchased scrap is divided into two general classifications: (1) dormant scrap and (2) prompt industrial scrap.

Dormant scrap comprises obsolete, worn out or broken products of consuming industries. Typical examples of dormant scrap are: discarded steel furniture, washing machines, stoves and other outdated consumer goods; beams, angles, channels, girders, railings, grilles, pipe, etc., arising from the demolition of buildings; useless farm machinery; obsolete, broken or damaged industrial machinery; old ships; railroad rails and rolling stock that have outlived their usefulness; wrecked automobiles, and so on. This type of scrap, because of its miscellaneous nature, requires careful sorting and classification to prevent the contamination of steel in the furnace with unwanted chemical elements from alloys that may be present in some of the scrap. It should also be of such physical size as to facilitate handling and loading into charging boxes. The need for proper classification and preparation of dormant scrap is emphasized by the existence of over 70 different specifications covering various grades of scrap for use in blast furnaces, acid and basic open-hearth furnaces, electric furnaces, the basic oxygen steelmaking process, gray-iron foundries and elsewhere. In addition, the Association of American Railroads has forty-five specifications applying to scrap of railroad origin. These all have been prepared to facilitate proper classification of scrap for different uses.

Prompt industrial scrap is generated by steel consumers in making their products. It may consist of the unwanted portions of plate or sheet that has been cut or sheared to the desired final size and shape, trimmings resulting from stamping and pressing operations, machine turnings, rejected products scrapped during manufacture, short ends, flash from forgings, and other types of scrap.